DOCUMENT RESUME

ED 347 307 CE 061 516

AUTHOR	Gallo, Dennis; And Others
TITLE	Production Technology Curriculum Materials FY 90. Illinois Plan for Industrial Technology Education.
INSTITUTION	Illinois State Univ., Normal.
SPONS AGENCY	Illinois State Board of Education, Springfield. Dept. of Adult, Vocational and Technical Education.
PUB DATE	Jun 90
NOTE	248p.; For related documents, see CE 061 514-518.
PUB TYPE	Guides - Classroom Use - Teaching Guides (For Teacher) (052)
EDRS PRICE	MF01/PC10 Plus Postage.
DESCRIPTORS	*Behavioral Objectives; Building Trades; *Construction (Process); Grade 9; Grade 10; High Schools; *Learning Activities; *Maintenance; *Manufacturing; Marketing; Technology; Troubleshooting
IDENTIFIERS	*Illinois; *Technology Education

ABSTRACT

This packet contains technology-based learning activities for the production technology course at the orientation level (grades 9 and 10) of the Illinois Plan for Industrial Technology Education curriculum project. The packet includes a course rationale, mission, description, and outline. Suggested learning objectives and suggested learning experiences for the following production areas are provided: introduction to production technology, construction technology, manufacturing systems, and servicing. The packet also contains over 30 student learning activities; representative topics are: installing and servicing new products such as computer systems and car stereos; organizing a student enterprise; packaging goods; and designing new structures. Numerous figures, scale drawings, and other graphics illustrate the text. (YLB)

****
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
****

ED347307

Illinois Plan for Industrial Technology Education

Production Technology Curriculum Materials FY 90

Project Staff:

Director:
Franzie Loepp

Developer:
Dennis Gallo

Contributors:
Daryl Floit
Kenneth Welty

Electronic Imaging:
Kathleen Hatch

Department of Industrial Technology

Illinois State University

Illinois
State Board of Education

Thomas Lay Burroughs
Chairman

Robert Leininger
State Superintendent
of Education

Department of Adult, Vocational and Technical Education

Vocational
Program Improvement
Section

June, 1990

PKAC22D

U.S. DEPARTMENT OF EDUCATION
Office of Educational Research and Improvement
EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)

☑ This document has been reproduced as received from the person or organization originating it.

☐ Minor changes have been made to improve reproduction quality.

• Points of view or opinions stated in this document do not necessarily represent official OERI position or policy.

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

T. Bellman

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC)."

CE061516

An Equal Opportunity/Affirmative Action Employer

BEST COPY AVAILABLE

TABLE OF CONTENTS

How to Use the Packet ii
Rationale, Course Mission iii
Course Description, Course Outline, Content Outline iv
Adapting to Nine or Eighteen Week Formats v

Introduction to Production Technology ..... i-I

Construction Technology ..... i-C

- Designing and Engineering a Construction Project 1-C
- Site Preparation and Surveying 20-C
- Erecting Structures 32-C
- Installing Utilities 41-C
- Enclosing/Finishing 45-C

Manufacturing Systems ..... i-M

- Manufacturing Technology Overview 1-M
- Research and Development 3-M
  - A. Identify the Problem 4-M
  - B. Gathering Information 9-M
  - C. Developing Preliminary Designs 13-M
  - D. Selecting and Refining a Design 15-M
  - E. Specifying the Design 18-M
  - F. Building and Testing a Prototype 25-M
  - G. Presenting a Design for Approval 28-M
- Establishing a Student Enterprise 36-M
- Organizing Management and Labor 40-M
- Financing the Enterprise 48-M
- Selecting and Planning a Production System 52-M
- Tooling-up for Production 58-M
- Engineering a Production Facility 61-M
- Statistical Process and Quality Control 67-M
- Preparing to Manufacture the Product 84-M
- Marketing the Product 86-M
- Closing the Student Enterprise 92-M

Servicing ..... i-S

- Overview 1-S
- Training 7-S
- Estimating 16-S
- Installing 27-S
- Maintaining 36-S
- Repairing 40-S
- OPTIONAL: Servicing Small Engines 50-S

HOW TO USE THE PACKET

This packet contains technology-based learning activities for the Production Technology course at the orientation-level (grades 9 and 10) of the Illinois Plan for Industrial Technology Education curriculum project. The materials supplement the 1989 Illinois Plan Orientation Curriculum Guide and were developed to complement hands-on workshops.

The materials were designed to enable teachers attending the hands-on workshops to implement the activities at their home school. Workshop participants are encouraged to use the materials as a model for future curriculum development.

The Production Technology Activity Packet includes a course rationale, course mission, course description, course outline, suggested learning objectives for each of the transportation areas, and suggested learning experiences.* The packet also contains over thirty developed learning activities. Several of the activities have been collected from earlier activity packets developed by the project. The packet also contains many newly developed activities. These include activities like Installing and Repairing, Manufactured Goods, Organizing a Student Enterprise, Packaging Goods, and Designing New Structures.

When implementing these activities, it is important to teach the resources, technical processes, industrial applications, and technological impact for each technology education topic. By including content from each of these areas, students are ensured a complete orientation. Content should also address integrated skills like transition skills, generalizable skills, and vocational ethic skills, as well as the State Goals for Learning. The content can be presented through short lectures, discussion, media, or demonstrations. However, most of the time should be spent on hands-on learning activities.

The following abbreviations are used in this document:

TA = Teaching Aid
SH = Student Handout
DR = Drawing

Acknowledgment

The development of these materials were made possible through a grant from the Illinois State Board of Education, Department of Adult Vocational and Technical Education, Research and Development section.

* Information taken from the 1989 Illinois Plan Orientation Curriculum Guide.

PRODUCTION TECHNOLOGY

Course Rationale

Throughout history, people have produced goods, constructed shelters, and provided services. Society places a high priority on these activities to improve the quality of life and facilitate economic growth. In order to maintain a high standard of living and continue economic development, these activities must constantly undergo significant changes. Changing technology has made it possible for industries to produce goods, construct structures, and provide services with more efficiency, greater accuracy, and fewer people.

The study of Production Technology can help students to develop an appreciation of the hands-on activities, technical advancements, technological impacts, and employment trends found within the manufacturing, construction, and servicing industry. Through learning experiences that include problem solving, decision making, group interaction, and technical development, a student can become more technologically literate. As a result of technological literacy, students will be better equipped to make rational career decisions, be wiser consumers, and cope with future technological advancements.

Since the educational system should provide curriculum conducive to developing a person's understanding of the world, then a study of materials and processes, manufacturing, construction, and servicing becomes a valid, and significant part of a student's plan of study. The production course can provide opportunities to learn content that is unique to the student's high school experience. There is no other area of the high school curriculum that can offer the student a chance to examine how our society produces, constructs, and services its goods, products, and structures. Through activities which employ a wide range of tools and materials in conjunction with extensive planning and processing skills used in industry, this course promotes an understanding of an industrial/technological society.

Course Mission

The purpose of the Production Technology course is to orient students to the basic resources, technical processes, industrial applications, and technological impacts related to manufacturing, construction, and servicing technology. The course will help students to:

* use and understand the verbal and symbolic language used to describe production systems and phenomenon;
* develop and present creative solutions to present and future production problems;
* identify and investigate potential career opportunities in the area of production;
* understand the evolution of production technology and its influence on our culture; and
* safely use common tools, materials and processes to design, build, and test production systems.

Course Description

The Production Technology course includes units on materials and processes, manufacturing, construction, and servicing. Each unit will involve students in a wide range of activities and experiences. Students' learning activities and experiences will include things like managing and organizing people; researching and developing products; producing and assembling goods; designing and building structures; testing and evaluating materials; generating plans and specifications; installing and servicing systems; and marketing and distributing finished goods.

Course Outline

In the spirit of orientation, students should be introduced to a wide range of materials and processes, manufacturing, construction, and service technologies. The following course outline lists the recommended units for either a nine or an eighteen week format. Potential lesson topics are provided under each unit title. Each lesson should embrace as many of the unit objectives as possible. In a nine week format, an emphasis should be placed on the terminology, resources, processes, applications, impacts, careers and safety concepts that relate to the lesson topic.

Sample Production Technology Course Outline

I. Introduction to Production Technology

II. Materials and Processes
- A. Materials
- B. Separating
- C. Forming
- D. Combining
- E. Molding/Casting
- F. Finishing
- G. Safety

III. Manufacturing
- A. Establishing Enterprises
- B. Financing Enterprises
- C. Research and Development
- D. Industrial Engineering
- E. Production
- F. Marketing
- G. Industrial Relations
- H. Dissolving Enterprises

IV. Construction
- A. Design Engineering
- B. Surveying and Preparating the Site
- C. Establishing Foundation System
- D. Building Superstructures
- E. Installing Utilities
- F. Enclosing and Finishing
- G. Marketing

V. Servicing
   A. Installing
   B. Maintaining
   C. Repairing

Adapting the Production Technology Course Outline to a Nine or Eighteen Week Format

Hands-on learning activities are one of the most powerful ways of helping students learn about technology. Unfortunately, they are very time consuming. The following strategies can be employed to use available laboratory time more efficiently without sacrificing important unit objectives:

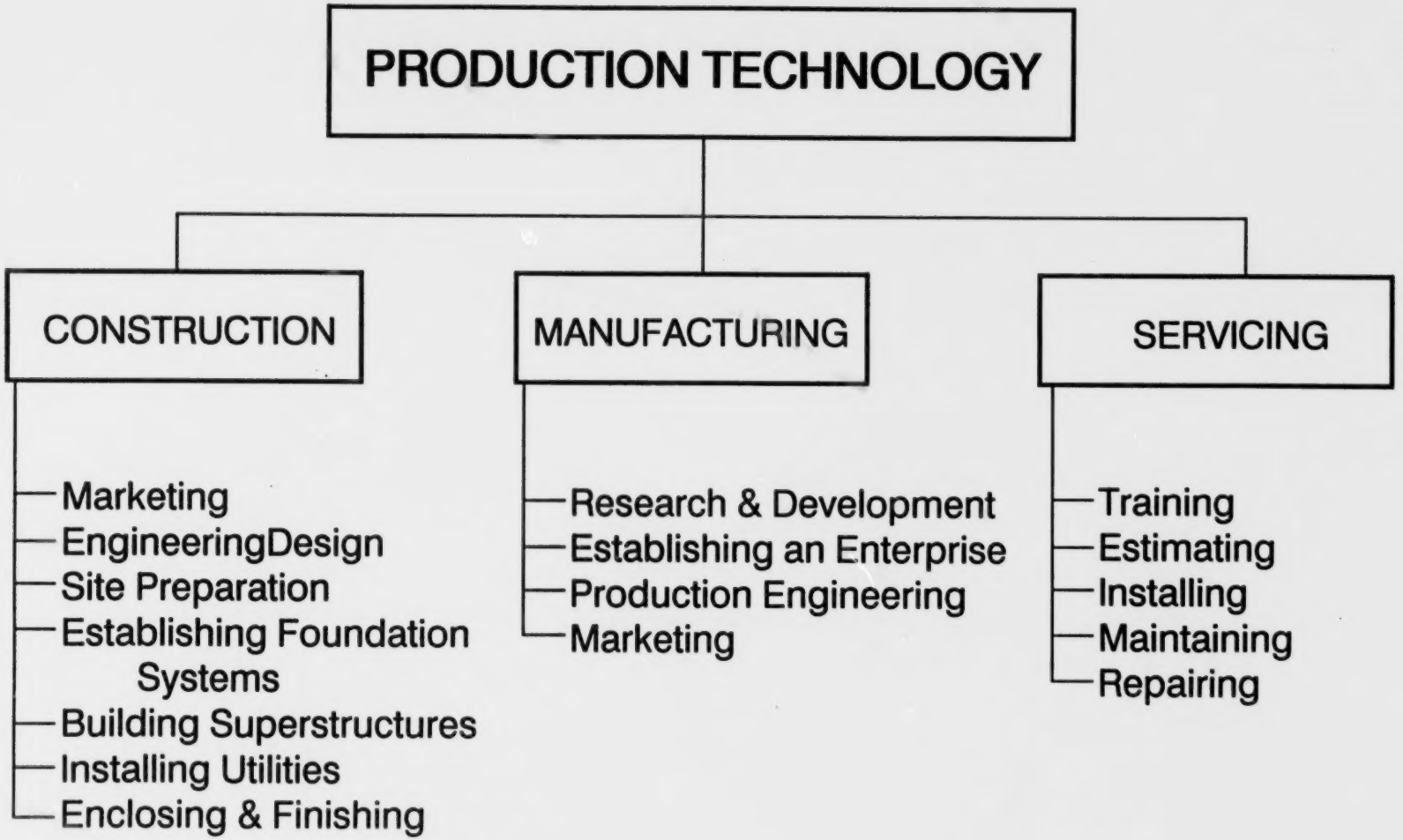
* Divide the class into small groups and assign each group a different learning activity related to the lesson topic. When each group has finished their assigned activities, have students present their experiences to the rest of the class. For example, during the materials and processes unit, have groups of students perform a variety of processes on different materials.

* Avoid assigning complex laboratory activities when simpler activities will enable students to experience important concepts and achieve the desired objectives. For example, during the manufacturing unit, have students manufacture a product with less than six parts instead of one with ten or more parts.

* Prepare work stations that organize the tools and materials needed to conduct laboratory activities prior to class. For example, during the servicing unit, develop the mock-ups students will use to install and service burglar alarms.

* Have students experience a wide range of concepts through one or two robust learning activities. For example, during the materials and processes unit, have students cast polystyrene beads. Discuss how the basic processes used to cast polystyrene beads transfer to other materials like polymers, ceramics, and metals.

During an eighteen week format, students can engage in more complex learning activities and experience given topics in greater depth. In addition, there is an opportunity to provide a wider range of learning experiences. The study of technology allows for an infinite number of learning experiences. Therefore, it is important to select and implement learning activities in an efficient manner.


PRODUCTION TECHNOLOGY
CONSTRUCTION
MANUFACTURING
SERVICING
Marketing
EngineeringDesign
Site Preparation
Establishing Foundation Systems
Building Superstructures
Installing Utilities
Enclosing & Finishing
Research & Development
Establishing an Enterprise
Production Engineering
Marketing
Training
Estimating
Installing
Maintaining
Repairing

INTRODUCTION TO PRODUCTION TECHNOLOGY

INTRODUCTION TO PRODUCTION TECHNOLOGY

Suggested Learning Objectives

Upon completion of the Introduction to Production Technology unit, students will be able to:

A. Define and properly use common production technology terminology like development, engineering, quality control, industrial service, management, and contracting.

B. Categorize production activities like building bridges, assembling automobiles, and repairing computers as manufacturing, construction, or servicing.

C. Describe the basic applications for production technology including making products, building structures and servicing goods.

D. Compare and contrast the roles of manufacturing, construction, and servicing on the American and international economy.

E. Describe the role of planning, organizing, staffing, directing and controlling in managing manufacturing, construction, and servicing activities and enterprises.

F. Describe the basic types of tools, materials, and processes used to produce goods, build structures, and provide services.

G. Explain why and how people work together in manufacturing, construction and service enterprises.

H. Recognize and provide examples of manufacturing, construction, and service industries in the community.

I. Forecast the consequences of low productivity and describe the technological strategies being used to enhance the United States competitiveness in international markets.

Suggested Learning Experiences

1. Introduce students to the concept of manufacturing. Describe manufacturing as those activities performed within a facility to produce a product. Using teacher-prepared jigs and fixtures and materials like balsa wood, cardboard, tooth picks or drinking straws, have students report to workstations and manufacture trusses for a bridge. Ask students to explain the importance of planning, cooperation, quality control, and efficiency when manufacturing products?

2. Introduce students to the concept of construction. Describe construction as those activities conducted on a site to build a structure. Using the trusses produced during the activity above, have groups of students construct a model bridge on a fixture representing a building site. Ask students to identify similarities and differences between manufacturing and construction.

3. Introduce students to the concept of servicing. Describe servicing as those activities performed to install, maintain, or repair finished products and structures. Using a teacher-prepared testing apparatus, have students apply a load to their bridge until it fails. Ask each group to determine why their bridge failed, identify appropriate modifications, and make necessary repairs. Have students discuss the relationship between manufacturing, construction, and service activities.

4. Discuss how manufacturing, construction, and service organizations contribute to a community's economy. Using reference materials like telephone books and/or newspapers, have students review advertisements and categorize local companies under the headings of manufacturing, construction, and service. Have students discuss the employment opportunities and the number of enterprises in each category. Ask students to determine the category making the biggest contribution to the local economy.

5. Discuss the new innovations and trends in production technology. Using magazines and newspapers with a wide circulation, have small groups of students make bulletin board displays identifying and illustrating the current trends in manufacturing, construction, and service industries. Ask students to describe the impact of new developments in production technologies on employment patterns, education requirements for employment, and quality of life.

CONSTRUCTION

CONSTRUCTION TECHNOLOGY

Suggested Learning Objectives

Upon completion of the construction technology unit, students will be able to:

A. Define and properly use common construction **terminology** like anchorages, cantilever, prefabrication, renovating, modular, liens, and geotextiles.

B. Identify basic **applications** for construction technology like constructing shelters, providing facilities for recreation and entertainment, establishing pathways, and building structures.

C. Describe the societal and environmental **impacts** associated with construction activities including eliminating wildlife habitats, altering landscapes, urbanization, and enhancing the quality of life. SC2

D. Describe the advantages, disadvantages, and potential **applications** for alternative building techniques and materials including pneumatic, geodesic, and fabric structures. SC2

E. Categorize the major **processes** used to construct buildings, structures, and pathways including designing the project, preparing the site, establishing the foundation system, erecting a superstructure, installing utilities, and enclosing and finishing structures.

F. Identify, describe and evaluate **career** opportunities in the construction industry (e.g., laborer, contractor, iron worker, architect) based on their interests, talents, and career expectations.

G. Identify potential **safety** hazards, establish guidelines for safe behavior, and adhere to common safety practices when around or participating in construction activities. PH3

H. Describe the major milestones in the **history** and the development of construction technology including building of the pyramids in Egypt, introduction of the arch, construction of the Panama Canal and the development of prefabricated components and structures. SS2

I. Identify basic natural, human, material, financial, technological, and information **resources** used in construction enterprises (e.g., lumber, construction loans, building codes.)

J. Apply the concept of tension and compression to design, build and evaluate a structure that will distribute and carry a given load. SC1

K. Assess the load carrying characteristics of various geometric shapes and configurations including arches, I- beams, trusses, domes, and hyperbolic paraboloid. SC2

L. Apply basic management processes like planning, organizing, staffing, directing and controlling to maximize efficiency during simple construction projects.

M. Describe the utility systems and services associated with structures, buildings, and pathways including sewage, electricity, natural gas, telephone, cable, and water.

N. Describe the various foundation systems used to distribute the weight of structures, buildings, and pathways including piles, piers, spread footings, and floating slabs.

O. Evaluate communities based on design considerations like providing utilities, establishing transportation systems, planning for expansion, and zoning for residential housing, commercial buildings, and industrial parks.

P. Use common tools, techniques and math principles to perform construction processes like engineering, surveying, squaring, leveling, estimating, and measuring. MA1

Q. Forecast the potential effects of innovative construction techniques on things like labor patterns, housing, energy utilization, and building time. SC2

R. Design, build, test, and evaluate a construction model, mock-up, or project that addresses a construction problem featuring cost, time, environmental, and/or societal considerations.

Suggested Learning Experiences

1. Demonstrate how folding and bonding materials can increase their load carrying capacity. Using a given amount of paper and glue, have each student design, build, and test paper structures that will carry a given load in either a vertical or horizontal position. Ask the students to describe how their structure distributes its load.

2. Demonstrate how trusses and beams are used to increase the strength of structures. Using a given amount of balsa wood, glue, straight pins, and a testing fixture, have each student design, build, and test a truss or beam. Have the students describe how their truss or beam distributes its load.

3. Introduce students to the concept of forming a construction enterprise. Divide the class into groups based on the number of construction projects to be addressed. Have each group establish, organize and name a construction company. Each enterprise needs to include an architect, a general contractor, and several sub-contractors (e.g., electrician, carpenter, mason). Discuss how the student enterprises compare to real construction companies in your community. Ask students to examine the company's responsibility to provide job and make a profit.

4. Discuss the various jobs and career opportunities in the construction industry. Have students apply and interview for positions in their construction company. Depending on the construction project, create positions that allow students to role play careers in

carpentry, masonry, landscaping, general contracting, designing, architecture, and structural engineering. Ask students to describe the factors needed to obtain a job in the construction industry. Include things like education requirements, work experience, interpersonal skills, and knowing how to be a good employee.

5. Introduce students to the processes used to design, plan, and engineer construction projects. Using traditional materials or computer-aided drafting and design tools, have a group of students prepare plans, specifications, and a presentation model for a construction project that addresses the needs of a real or fictitious client. The client's needs can be expressed in the context of a storage building, room addition, vacation home, or small office. Have each design and engineering team evaluate their plans and specifications in terms of things like energy, cost, lighting, function, appearance, safety, maintenance, zoning, traffic, and structural considerations.

6. Explain the importance of scheduling to maximize efficiency during a construction project. Have each construction company complete a schedule identifying and sequencing the people, materials, equipment, and processes needed to complete their construction project on time. Make sure each schedule includes things like when given materials should be delivered to the site, when the construction project will be inspected, when students will need special tools, and when students will be performing given tasks. Discuss how the saying "proper prior planning prevents poor performance" applies to the construction industry. Ask students to identify the consequences of poor planning on things like safety, cost, and profit.

7. Introduce students to the processes involved in preparing bids and estimating the cost of a construction project. Using the plans and specifications, basic formulas for estimating materials, labor and price lists, have each subcontractor determine the cost of performing their assigned construction task. Require each subcontractor to prepare and submit a bid to the general contractor. Ask the general contractor to prepare and present a proposal describing the material, equipment, labor, overhead, and total project cost to a real or fictitious client. Ask the students to discuss the consequences of inaccurately estimating and bidding on construction projects.

8. Discuss why communities require builders to obtain building permits before starting construction or remodeling projects. Using a simple check list, have students exchange and evaluate the plans and specifications developed during the activity above. When the plans and specifications meet the defined criteria, grant the student's company a building permit to begin their construction project. Discuss the role of building permits as a means of maintaining community standards and ensuring quality construction.

9. Introduce students to the concept of surveying. Using commercial or constructed transits and level rods, have small groups of students lay out and level four or more stakes for a fictitious construction project. Possible construction projects could include things like decks, garages, or driveways. Discuss the role of surveying in preparing maps, establishing property lines, and laying out pathways.

10. Introduce students to the basic processes used to construct buildings. Using common construction materials, fasteners, tools, equipment, and hardware, have groups of students design and build small storage sheds. Include tasks like establishing a foundation, framing a superstructure, installing a utilities system, and enclosing and finishing the building. Have the students compare and contrast the processes used to build the sheds with those used to build houses, commercial buildings, and industrial complexes.

11. Introduce students to the basic processes used in constructing a building. Include things like preparing the site, establishing a foundation system, erecting the superstructure, installing the utilities, enclosing the superstructure, and finishing the project in your discussion. Using materials like plywood for a site, mortar mix for a foundation system, foam core for the structure, and small electrical components for a utility system, have groups of students build an architectural model for a simple structure (e.g., vacation home, storage buildings, room addition, small office). Have the students compare and contrast the processes used in designing and building their model with those used in building residential and commercial structures.

12. Introduce students to the concept of pneumatic structures. Using materials like plastic, duct tape, caulking and a fan, have groups of students design, build, test, and present a pneumatic structure that addresses a problem. Possible problems could include developing a new kind of tent, temporary emergency shelters, or enclosing arenas. Ask the students to evaluate the energy requirements, weather resistance, and structural strengths and limitations associated with pneumatic structures.

13. Explain how geodesic domes are structures based on a network of triangles. Using materials like paper, drinking straws, or dowel rods, have small groups of students build a two frequency geodesic dome. Ask the students to discuss the structural strength of domes, how changes in the frequencies effect the dome's shape and size, and the need to connect several geodesic domes together to make a multi-purpose building.

14. Introduce students to the concept of fabric structures. Using materials like cloth, string, duct tape, and dowel rods, have groups of students design, build, and present a fabric structure that addresses a problem. Possible problems could include roof to a stadium, pavilion for a park, and/or modern architectural sculpture. Have students compare the structural, cost, engineering, and aesthetic characteristics of fabric structures with conventional structures using traditional building materials and techniques.

15. Present the basic processes used to construct buildings. Using typical construction materials, fasteners, tools, and equipment, have groups of students design and construct a corner section. The corner section should include a foundation, floor, wall, and roof system. Consider having students perform tasks like forming concrete, framing openings, and enclosing the interior and exterior of the structure. Have the students compare and contrast the processes they used to build their corner section with those used to construct homes, commercial buildings and industrial complexes.

16. Explain how foundation systems distribute and transmit structural loads to the earth. Using tools and materials like damp sand, concrete blocks, and masonry tools, have small groups of students construct, level, and plumb a three foot high by six foot long wall. Have students describe the structural and financial implications of a bad foundation system.

17. Introduce students to basic utility systems that are installed during the construction process. Using materials like PVC pipe, receptacles, telephone jacks, and heating ducts, have groups of students install the electrical, plumbing, communication, and climate control systems into the corner section constructed during the activity above. Ask the students to identify the utility systems installed in homes, commercial buildings, and industrial complexes.

18. Introduce students to the concept of building codes and inspection during the construction process. Using a simple check list, have students inspect construction projects being built by other groups. Have students evaluate things like stud spacing, the dimensions of structural members, the number of wires in a junction box, and the size of the plumbing vent stacks. Have students explain why building codes need to be established and enforced. Discuss the consequences of code violations.

19. Introduce students to the concept of community planning. Using materials like cardboard, foam core, balsa, glues, dowels, and string, have students design, build and present an architectural model for a new community based on a given problem statement. Possible design considerations could include climate, natural resources, geographical features, and culture. Each model and presentation should account for things like recreation, transportation, residential housing, commercial enterprises, industrial complexes, utilities systems, and community services. Ask students to explain how good planning, or the lack of it, has effected the quality of life in their own community.

20. Discuss how construction sites, materials, techniques, and processes might be different in the future. Using materials like cardboard, paper plates, styrofoam cups, drinking straws, and glue, have a group of students design, build and present models describing cities of the future. Possible sites for the futuristic communities could be on the ocean, under water, in space, underground, on the moon, and/or on another planet. Models and presentations should describe the facilities for things like producing food, products, and structures; transporting people and goods; communication information; providing and utilizing energy; recreation and entertainment; and waste disposal. Discuss how location influences how people design and construct buildings and structures. Ask students to describe how buildings effect the way we live, work and play.

21. Discuss the milestones in the history and evolution of construction technology. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.

DESIGNING AND ENGINEERING A CONSTRUCTION PROJECT

Introduction

Once a site has been selected, typically the next step is to design the structure. During the design process, the project moves through several stages. These stages include:

- Identifying a client's wants or needs
- Develop preliminary designs
- Evaluate and select the best design
- Specify and refine the design
- Generate renderings and/or presentation model
- Prepare final plans and specifications
- Present final design and specifications to the client

Whether it is a family wanting a new home or a city wanting a bridge replaced, all construction projects must meet the needs of the client. An architect or engineer is a person who plans and designs the structure. Architects typically work with the client and identify their needs and wants. Engineers determine the detail (e.g., size of beams, heating requirements, types of materials). Needs can be identified through a face-to-face meeting between the client and the designer. For example, in a meeting with city leaders who want a new bridge built, the architect may ask questions like: How many people are expected to use the bridge? Are there plans to develop the area near the bridge? If so, what type of development is being considered? Is the bridge near a business district or residential area? What is the bridge spanning over (e.g., river, railroad tracks, another road)? What is the make-up of the land surrounding the project site? Through this type of questioning, the designer can begin to determine the type of bridge to build, as well as, forecast short term and long term use of the bridge. The architect may consult a civil engineer about the design being planned.

Once a client's needs and wants have been established, the architect begins to generate several ideas. To better visualize the idea, the designer will draw a thumbnail sketch. Thumbnail sketches play several important roles in the design process. First, the sketch helps the architect visualize their ideas. Secondly, it allows the designers to store their ideas and create more. Lastly, it helps the designers communicate their ideas to others.

The next step is to evaluate each design. The purpose of the evaluation process is to identify the best design. Architects and engineers use a list of design considerations to evaluate each preliminary design. A typical list of design considerations might include things like:

-	Function	Does the design meet the needs of the client or will the design do what it is suppose to do
-	Appearance	Is the design pleasant to look at?
-	Safety	Is the design safe to construct and use?
-	Ease of servicing	Can the design be maintained and serviced easily?
-	Market Appeal	Will people fund or purchase the design?
-	Cost	How much will it cost to construct the design?
-	Ease of construction	How hard will it be to construct the design?
-	Durability	How long will the design last?

Other design considerations include zoning laws, building codes, and local covenants. Zoning laws regulate how dense (e.g., how many people or structures can be located in a given area of land), and the types of structures that can be built in a given area of land. For example, a community may be divided into commercial, residential, or industrial zones. This means the area stated as residential can only have residential structures (e.g., homes, condominiums, apartments). An area zoned as commercial could have structures like malls, fast food restaurants, and grocery stores. Factories would be built in areas zoned as industrial.

Building codes regulate how a structure is built and the quality of the materials used to build it. An office building, for example, may have building codes which regulate the type of electrical wiring used or the quality of concrete used in the foundation. A bridge spanning over a river may have to use steel beams which are of a specific grade and thickness. Another building code may specify the width of a highway intersection or the height of an overpass (a road or bridge going over another road).

Local covenants or ordinances help regulate specific parts or sections of a community. A residential area in one part of the community may require all homes be built at least 2,000 square feet or bigger. Other covenants may specify that the property must be landscaped using a particular species of tree or shrub. There may be a local covenant that states all structures in the area must have a brick exterior or natural wood siding. Covenants help keep neighborhoods consistent and protect owners' investment. Nobody want to invest in a nice house, to have a neighbor build a structure that is an "eye sore".

Zoning laws, building codes, and local covenants protect the owner's investment, provide safety standards, and help maintain the quality of life in the area. They must be followed when designing a structure.

At the end of the evaluation process, one design might prove to be the best. Or, a combination of ideas from several designs might be combined to make the best design.

Once the best design has been identified, it needs to be refined (improved). Architects and engineers refine designs by making detailed drawings and/or models. The drawings help the architect or engineer discover what the final design will look like and how it can be constructed.

To refine a design through drawings, a designer must first draw a rough sketch. A rough sketch is larger and includes more detail than a thumbnail sketch. After drawing a rough sketch, the designer is ready to develop a rendering. A rendering is a very lifelike picture of the design. Sometimes, they are so lifelike they look like photographs. They include a lot of detail and are often drawn in color. Since the renderings are so lifelike, they can be used to ask the client what they think of the design before it is built.

Drawings can only provide a two dimensional representation of a design. The primary advantage of an architectural model is it can represent the design in three dimensions. Typically, models are made of easy-to-work materials like paper, cardboard, foam core, wood, plastic or styrofoam. Models are very helpful when presenting the design to a group or explaining the design to a client. Models also allow architects and engineers to see what the structure will look like without spending a lot of time and money.

The next step of the design process is to determine how the structure is to be built. Architectural and/or engineering drawings must communicate to the builders how the structure is to be built. This information is typically, transmitted through a set of drawings called working drawings. For example, a set of working drawings for a residential house may include a:

- Plot plan	Plot plans show the site as seen from above. The plot plan shows things like location of the structure on the lot, building lines, distances, side walks, driveways, landscape, streets, and elevation heights (see Dr. #1).
- Foundation plan	Foundation plans show the buildings substructure. The substructure is what the main structure is built on. The foundation plans show the foundation walls and footings (see Dr. #2).
- Floor Plan	Floor plans show the house as seen if the structure was sliced horizontally and the top removed. A simple floor plan shows things like room location and size, along with, wall, door, and window locations (see Dr. #3). The floor plan is one of the most used drawings. From the floor plan other drawings such as electrical (see Dr. #4) and mechanical plans can be developed.
- Elevations	Elevations show the finished appearance of the structure. Typically, a set of working drawings will include the outside view of each side. Elevations provide information about the overall style of the structure (see Dr. #5 and #6).
- Detail Plans	Detail plans show special features of the structure. Detail plans may be needed to show special features like fireplaces, stairways, and cabinets (see Dr. #7).

A set of drawings for a new bridge project, may include civil or structural drawings. Civil drawings show how the structure will relate to the land on which it will be built. Civil drawings indicate where the land around the project will be filled or cut away in order to support the structure. Structural drawings show the structural parts of the project. Structural drawings show a cross section of the structure, location of the parts, size and type of material used, and how parts are to be fastened.

Before a construction project design can be built, it must receive the approval of the client. This process could be a simple face-to-face meeting or a formal presentation. A couple planning to build a residential home, for example, may meet with the architect who would explain the design, discuss the various drawings, and go over the cost of the project. A large construction project (e.g., bridge, highway off ramp, skyscraper, shopping mall) may require the approval of a city board and the financial institution. This requires a formal presentation. During the presentation, the architect or engineer may explain the overall project's design and projected cost, possible funding sources, and the environmental and economic impact on the community.

This Technology Education Activity will provide students with the opportunity to experience several design activities related to the development of a simple residential structure. As a part of this activity, students will identify a client's needs, develop possible design solutions, create a set of working drawings, estimate construction cost, prepare a presentation model, and present the design to the client.

Materials and Supplies

- Plain white sketching paper
- 1/4" grid paper (14" x 17" sheets)
- 1/8" grid paper (14" x 17" sheets)
- Construction paper
- Construction materials like balsa wool, foam core, or card board.
- Utility knife
- Hot melt glue gun and glue sticks
- Rubber cement
- A ruler or scale
- Traditional drafting equipment (e.g., triangles, t-squares)
- Plot layout sheet, SH #1
- Peer evaluation sheet, SH #2
- NOTE: Details can be added to some of the working drawings (e.g., plot plan, electrical plan, floor plan, elevations) by using a computer and a simple CAD program or with the assistance of architectural symbols templates (e.g., furniture, electrical, exterior texture, landscape).

Problem Statement

David Ryan is an out-of-state business man who has recently purchased a lake side lot in the resort community of Lake Brook. On the lot, Mr. Ryan plans to have a summer home built. Since he is not from the area, he has chosen to have a local architect design the summer home. After inquiring at several locations, Mr. Ryan has selected several firms in the area to prepare design ideas. Your company, Design Tree Inc., is one of the firms selected to submit a proposal. As a member of Design Tree's architectural design team, you have been assigned the task of creating a design proposal.

In a meeting with Mr. Ryan and his wife, your team discovered that the couple has two boys; Alex, age 7 and Jason, age 11. Additionally, the family has a golden retriever puppy named Frisky. Both boys and the family pet will be staying at the home during the summers.

Along with information about the family, Mr. and Mrs. Ryan described several features they want included in the design. First, they indicated they prefer an open floor plan. They want the kitchen to open into a larger room. Additionally, they want a view of the lake from the family room and the master bedroom. To add privacy and keep the rustic look, they both felt it was important to keep as many trees as possible. Finally, they both want an area outside the house to relax and look out across the lake. Mr. Ryan also wants this area illuminated with some type of exterior lighting.

Since this is a summer home, the couple want to keep it small and quaint. They also want to keep the cost at $40,000 or below.

Certain zoning laws, building codes, and local covenants might affect the design. Some of the laws, codes, and ordinances affecting the Ryan's neighborhood follow.

Zoning Laws

- The area where the Ryan's plan to live is zoned residential and is a single family dwellings only.

Building Codes

- All structures in the area must be set back at least 7' from side property lines. This space between the property line and the structure is called the set-back. The structure must also have a setback of at least 27' from the back property line and 40' from the center of the street.
- Minimum size for a bathroom is 6 feet x 8 feet.
- Minimum size for a bedroom is 10 feet x 12 feet.
- Minimum size for a kitchen is 10 feet x 10 feet.
- All footings must be at least 2 feet (24 inches) below grade.
- Foundation walls must be at least 8 inches wide.
- All concrete slabs must be constructed with at least 4 inches of reinforced concrete.
- The structure must have at least two exits to the outside.
- Inside receptacles must be located on the average every 12 feet of wall space, except in the kitchen. In the kitchen, receptacle should average every 4 feet of wall space.
- Ground fault circuit interrupters (GFCI or GFI) receptacles must be used in areas where people may ground themselves. These areas include bathrooms, kitchens, water faucets, and outside. A GFI is designed to automatically shut off when a preset amount of current is detected on a conductor.
- All kitchen receptacles must be on split circuits. This means the receptacle will be wired to various circuits, thus helping to prevent any overloads when more than one appliance is used in the kitchen.

Local Covenants

- All residential structures in the Ryan's neighborhood must be 850 square feet or less.
- All residential structures must be built on a slab foundation system.
- In order to maintain the wooded nature of the area, residents must retain at least 60 percent of the trees of the original log.
- The exterior surface of any structure must be covered with natural material (e.g., wood siding, stone).
- Each resident may have up to one vehicle parked along the street. The vehicle must be maintained and in working order.
- Lawns must be well kept and the grass be no taller than five inches.
- All garbage containers can be placed near the curb only after 6 o'clock P.M. the night before the regularly scheduled day of collection. The containers must be removed by 6 o'clock P.M. on the day of pick-up.
- Fences must be made only with natural materials (e.g., wood, stone).

Based on the information provided, it is up to you and your team to develop a set of working drawings (e.g., plot plan, floor plan, electrical plan, elevations, foundation plan), presentation model, and estimated cost.

Activity Procedures

1. Your instructor will divide the class into groups of two or three.

2. Obtain the plot plan and some plain paper from your instructor.

3. Carefully reread the problem statement. As you, read, try to identify any needs discussed by the client. Additionally, pay close attention to the section containing information about the area's zoning laws, building codes, and local covenants.

4. Using the problem statement and plot plan as a guide, begin to visualize and brainstorm as many preliminary designs as possible. Use the sketch paper to record your ideas.

5. Once again using the sketch paper, draw a thumbnail sketch for each design. Keep your ideas small and simple. Do not worry about neatness and accuracy. Do not evaluate your ideas. Concentrate on creating and recording.

6. In your design team, use the questions listed below to discuss and evaluate each of your preliminary designs. Try to find good ideas in each design. During the evaluation process, write notes on each sketch that identify good ideas and possible problems.

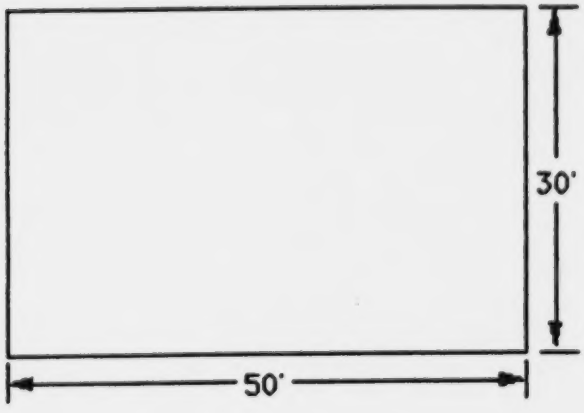
   - Does the design meet the needs of the client?
   - Does the design meet area zoning laws, building codes, and local covenants.
   - Is the design pleasant to look at?
   - Can the design be maintained and serviced easily?
   - Does the cost of the design stay within the given budget?
   - How hard will it be to construct the design?
   - Will the design hold up to normal wear and tear?

7. When you have finished evaluating each design, review your notes and select the best design. You may find one idea is clearly the best. However, you may need to combine good ideas from several designs to create the best design. Make sure your best design meets all the design considerations, zoning laws, building codes, and covenants.

8. After you have finished evaluating each design, the one selected as the best needs to be refined. The first step in the refinement process is to develop a final sketch. Your final sketch should be larger and include more detail then your thumbnail sketches. Try to improve your design as you draw. Do not be afraid to make changes.

9. Once your group has settled on a design, the next step is to calculate the cost of the project. A simple technique used to estimate the cost of residential construction projects is to find the area the structure is going to occupy and then estimate the cost of construction per square feet. A house, 30 ft. x 60 ft. for example, would have an area of 1800 square (the area of a rectangle is equal to the length of one side times the width of one side. In this case 30 ft. x 60 ft. = 1800 sq. ft.). If the cost of construction is estimated to be $50 per square foot, then to find out the estimated cost of a house 2400 square feet, you multiply the number of square feet by the cost per square foot. In the example above, the estimated cost would be $90,000 (1800 sq. ft. x $50.00 per sq. ft. = $90,000). Even though this technique is simple, it is not as accurate as some other methods. The final price can vary depending on the complexity of the design and the materials used to build the structure. Even so, this will be the technique used to estimate the cost of your design.

10. Begin estimating the cost of your design by determining the total area of the house. If the house is square or rectangular, multiply the length of the house by the width of the house (see illustration below).



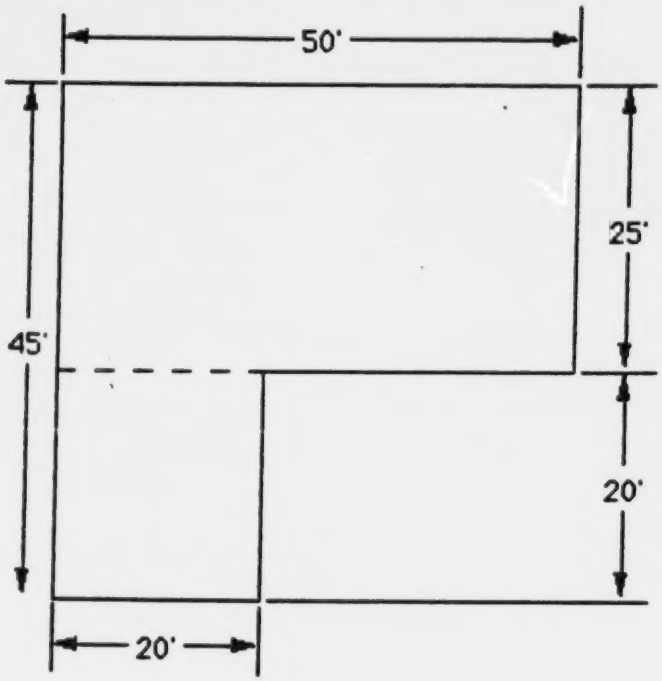
Length times Width = Area

50 ft. x 30 ft. = Area

50 ft x 30 ft = 1500 sq. ft.

Area = 1500 sq. ft.

If the house as an L-shaped or U-shaped design, then break the house down into several small squares or rectangles (see illustration below) and then add the totals of each square together.



Length times Width = Area
Area of the large rectangle
25 ft x 50 ft. = Area
25 ft. x 50 ft. = 1250 sq. ft.

Area of smaller square
20 ft. x 20 ft. = Area
20 ft. x 20 ft. = 400 sq. ft.
Area of each square added together equals total square footage.

Area of large rectangle = 1250 sq. ft.
Area of smaller square = 400 sq. ft.
Total square footage = 1650 sq. ft.

11. After calculating the total area of your design, the next step is to multiply the total area by the estimated cost of construction. The cost of constructing a residential structure in Lake Brook is estimated to be $50.00 per square foot. Following the steps listed below, calculate the estimated cost of your design.

    What is the total square footage of your design?_____

    What is the cost per square foot in the Lake Brook area?_____

    Total area times cost per square feet = estimated cost

    (Total area)_____ x (cost per sq. ft.) _____ = _____?

    Is the estimated cost of your design within the Ryan's price range? If not, modify your design and recalculate the estimated cost.

12. After calculating the cost and modifying the design, then use the 1/4" graph paper to develop a final sketch of the design. The final sketch should contain more detail and should be neatly done.

13. Using the final sketch as a guide, use the materials provided by your instructor to make a presentation mock-up. It should be noted that the mock-up will provide a representation of the structure and will not contain a lot of specific detail. NOTE: make sure to protect the table when you are cutting and gluing materials.

14. Once the final sketch and mock-up are complete, develop a set of working drawings. NOTE: Before beginning, have your instructor explain how to create each type of drawing found in the set of working drawings. After receiving instruction, use traditional or computer-aided drafting techniques, to develop a simple plot plan, foundation plan, floor plan, electrical plan, and elevations. Each member of the design team should create one or more of the drawings. For example, one team member could draw the plot plan and foundation plan, another team member could draw the floor plan and electrical plan, and another team member could draw the elevations.

15. When the mock-up and working drawings are finished, it is time to present your idea to Mr. and Mrs. Ryan.

16. Your team has worked hard to develop the best design. Other local firms have also worked hard to develop designs. However, the Ryan's only will select one design. It will be up to your design team to convince the Ryan's your design is best.

17. Each design team will be given an opportunity to present their design. Your team needs to prepare a presentation that includes a set of working drawings, a mock-up, and an estimated cost. You may want to assign each team member a topic. Your presentation could center around a display. The display could feature rough sketches, preliminary drawings, working drawings, a mock-up, and a cost analysis sheet. During the presentation, team members could refer to the display. At the end of your presentation, ask the Ryan's (the class) if they have any questions.

18. When finished planning your presentation, conduct a rehearsal. During your rehearsal, practice speaking your lines clearly, making eye contact, and using visuals. Also, take turns asking and answering questions.

Activity Analysis

1. A type of drawing that communicates room locations and sizes is called _____?

   a. Plot plan
   b. Floor plan
   c. Elevations
   d. Detail Plans

2. A type of drawing that communicates building lines, sidewalks, and structure location is called _____?

   a. Plot plan
   b. Floor plan
   c. Elevations
   d. Detail Plans

3. A type of drawing that communicates the overall style of the structure is called _____?

   a. Plot plan
   b. Floor plan
   c. Elevations
   d. Detail Plans

4. The first step in the design process is to _____?

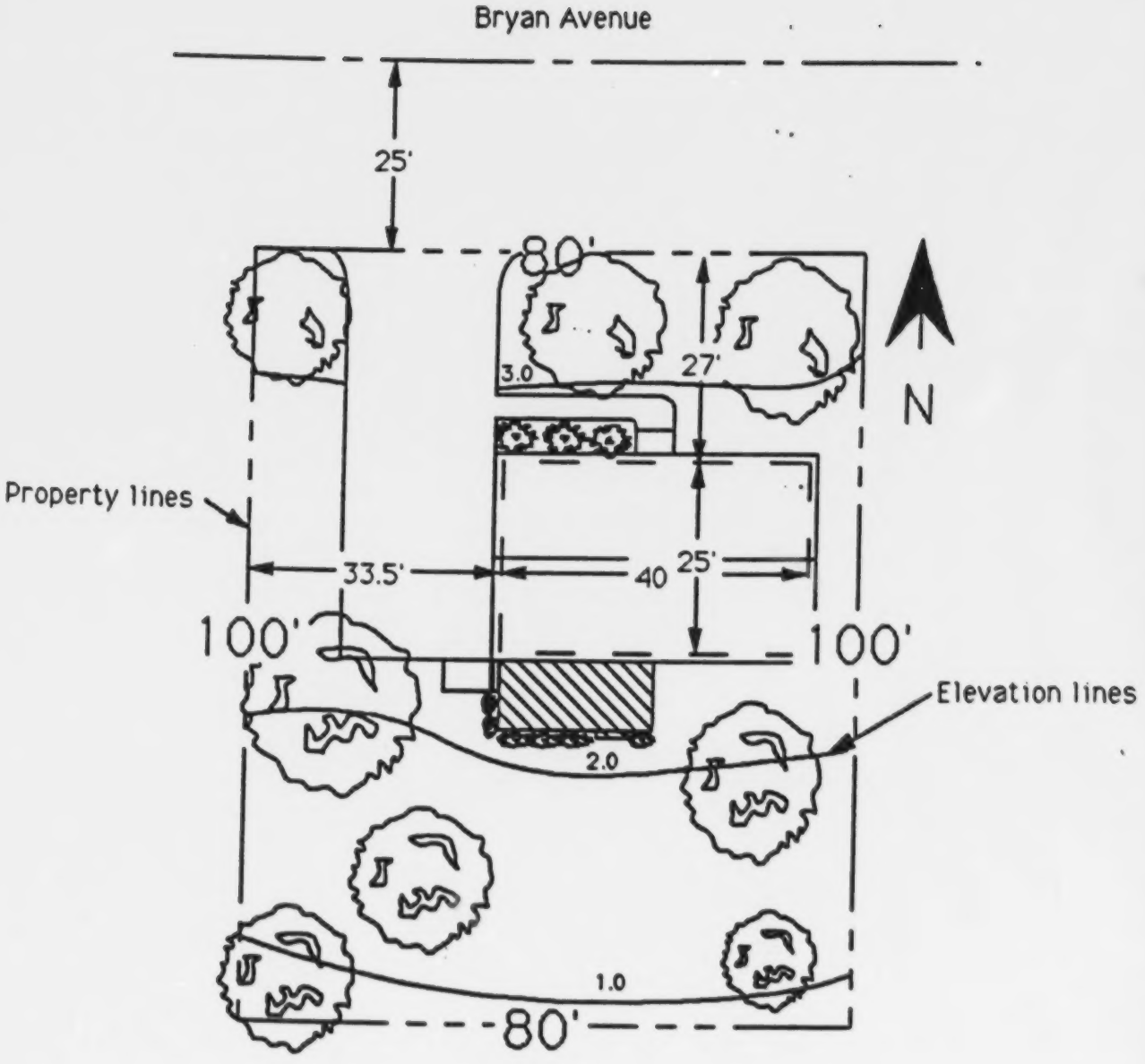
   a. Prepare final drawings
   b. Prepare a presentation model
   c. Evaluate and select the best design
   d. Identify a clients wants or needs

5. The ares of construction which regulates the type and quality of building materials used is called _____?

   a. Zoning laws
   b. Building codes
   c. Covenants

6. The area of construction which regulates the type of structure being built and the density of people and buildings is called _____?

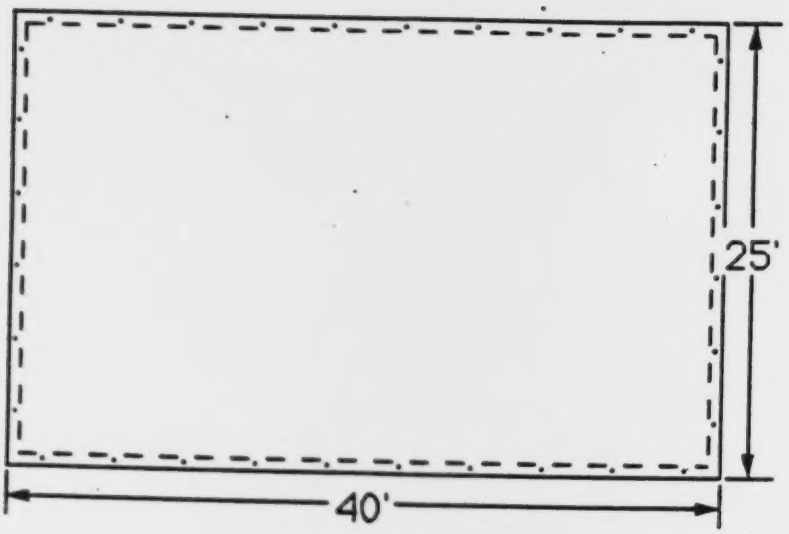
   a. Zoning laws
   b. Building codes
   c. Covenants



PLOT PLAN

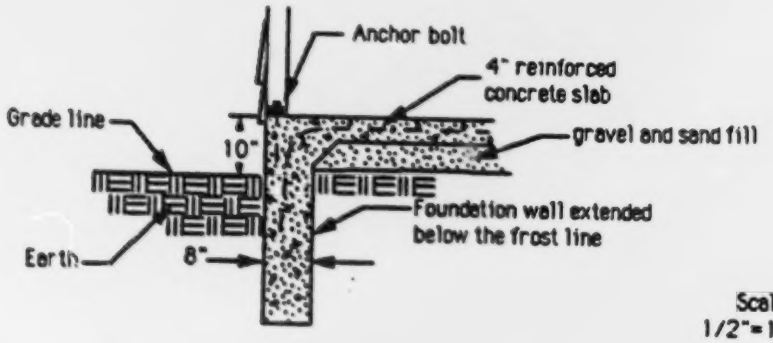
Scale
1"=20'

11-C



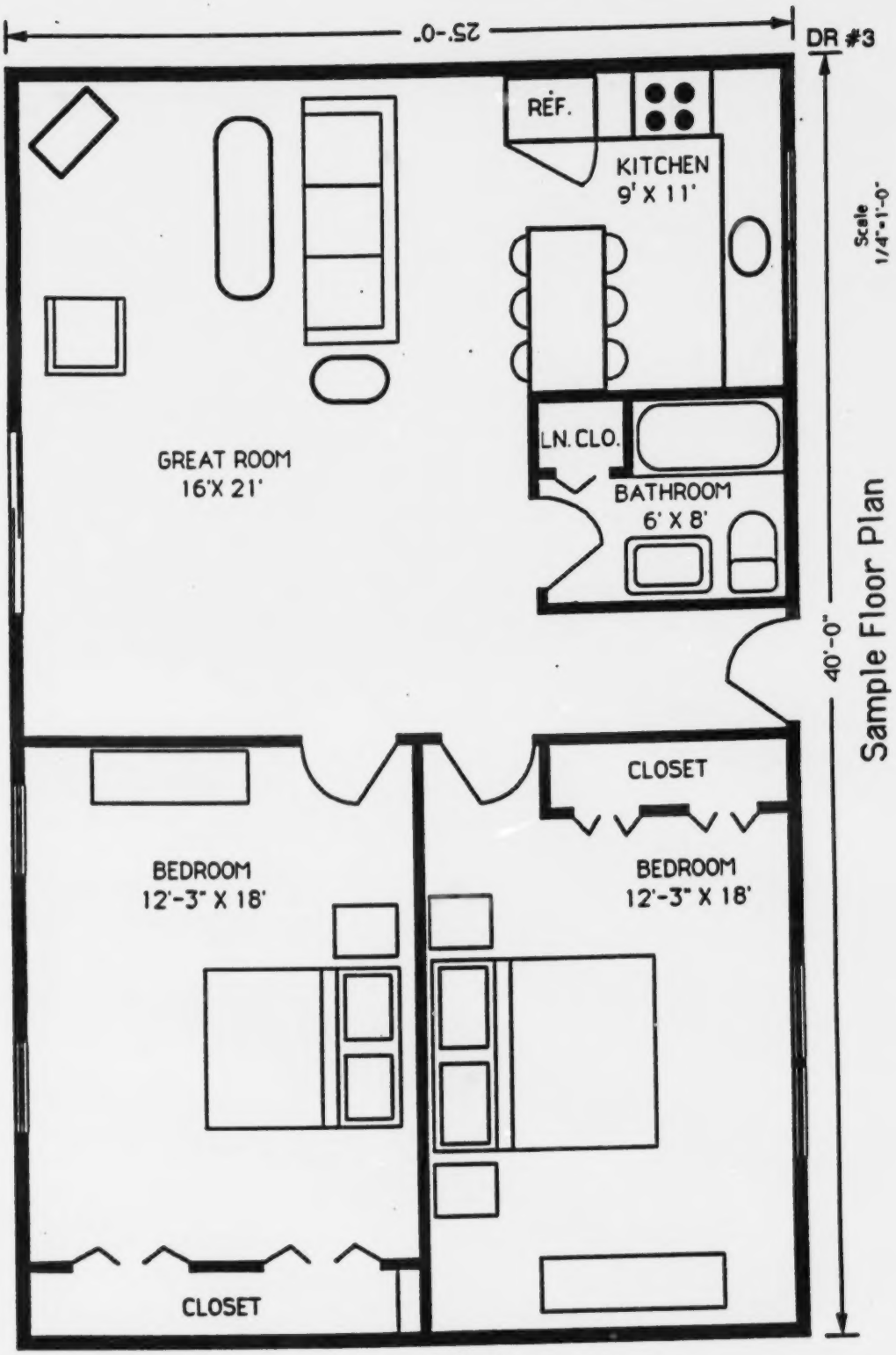
Sample Foundation Plan
for a slab footing and foundation

Scale
1/8"=1'-0"



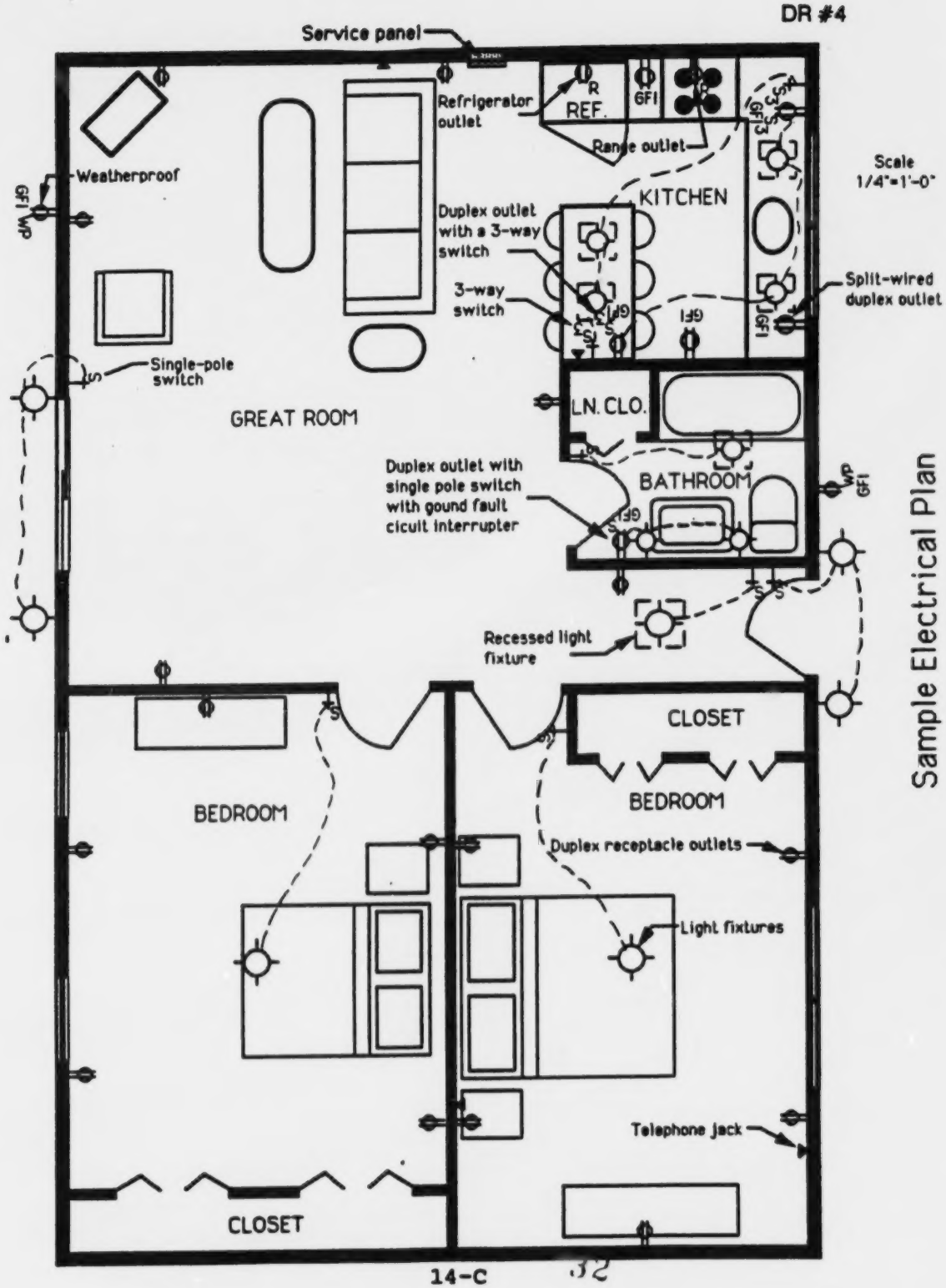
Scale
1/2"=1'-0"

Sample Foundation Section
for a slab footing and foundation


25'-0"
DR #3
REF.
KITCHEN
9' X 11'
GREAT ROOM
16'X 21'
LN. CLO.
BATHROOM
6' X 8'
40'-0"
Scale
1/4"-1'-0"
Sample Floor Plan
CLOSET
BEDROOM
12'-3" X 18'
BEDROOM
12'-3" X 18'
CLOSET

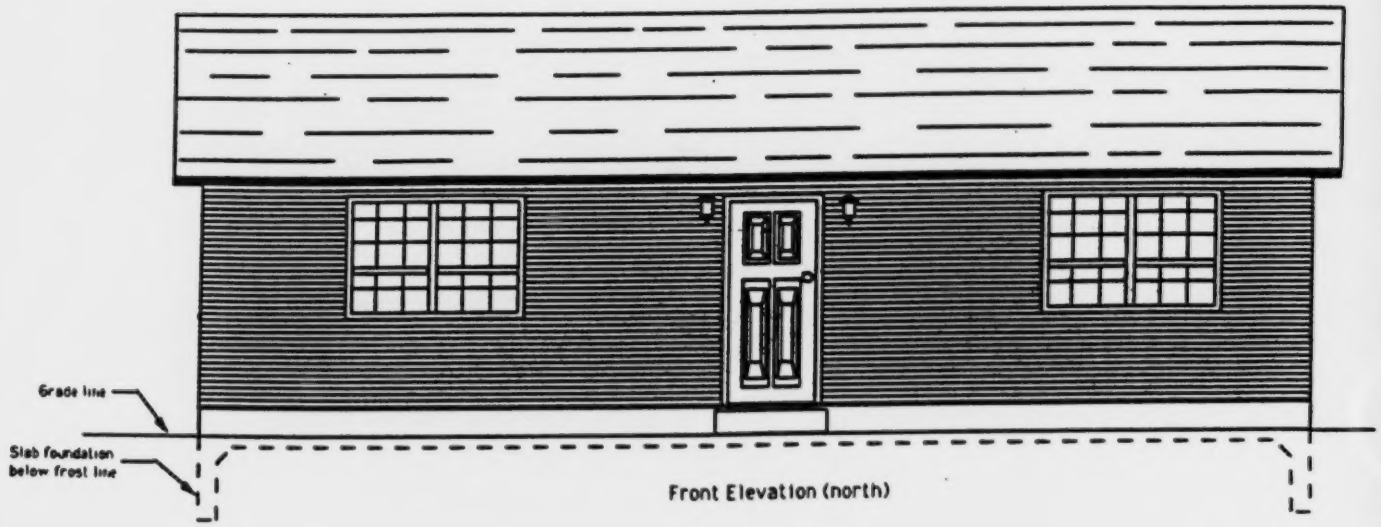
13-C

DR #4



Scale
1/4"=1'-0"

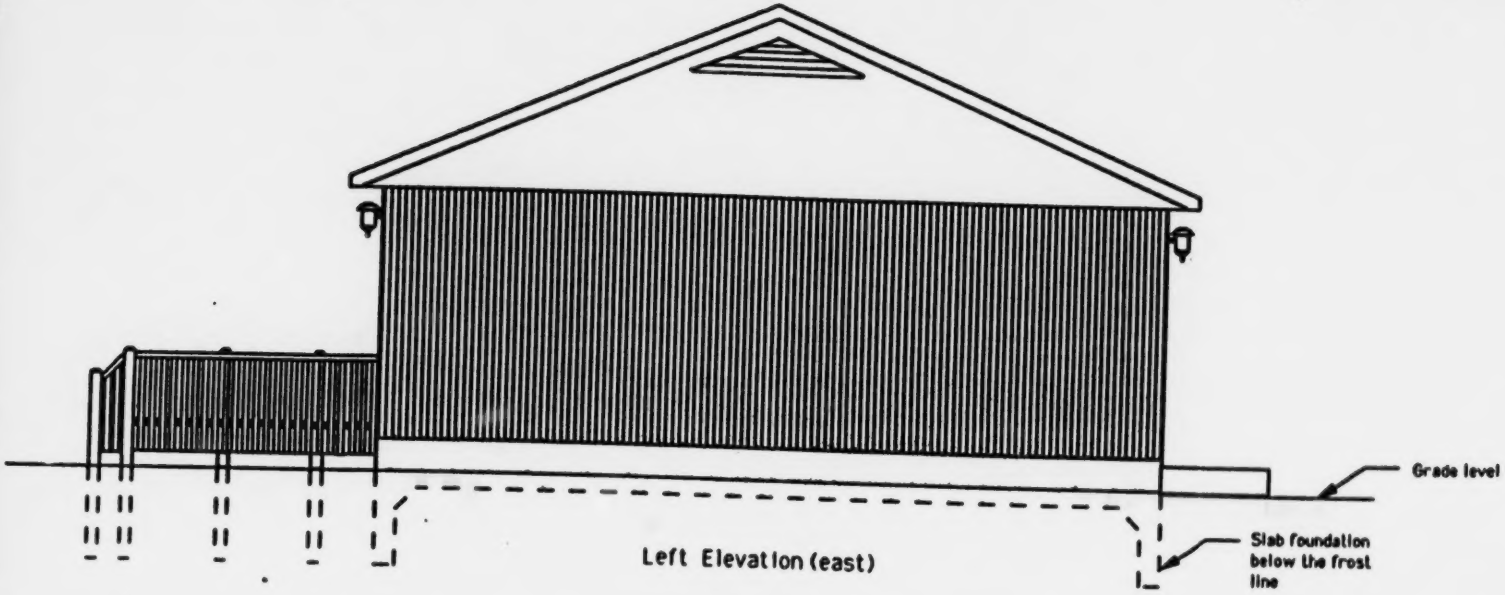
Sample Electrical Plan



Front Elevation (north)

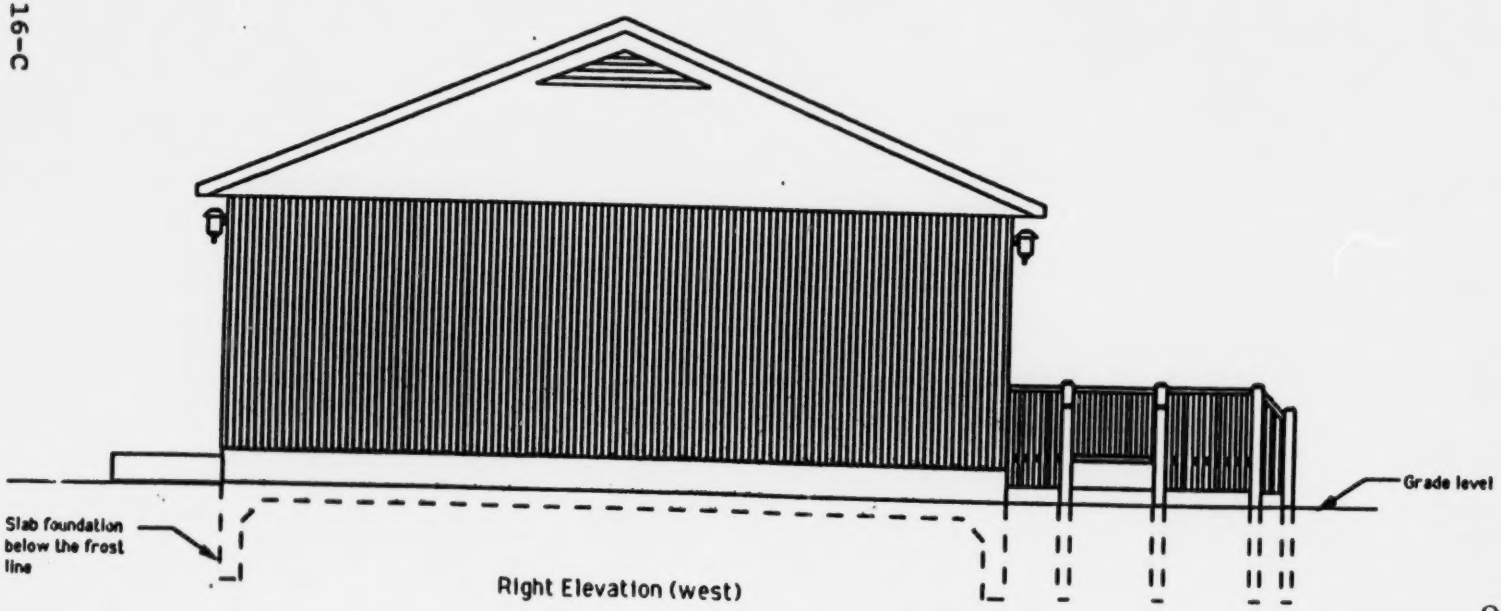
Back Elevation (south)

15-C



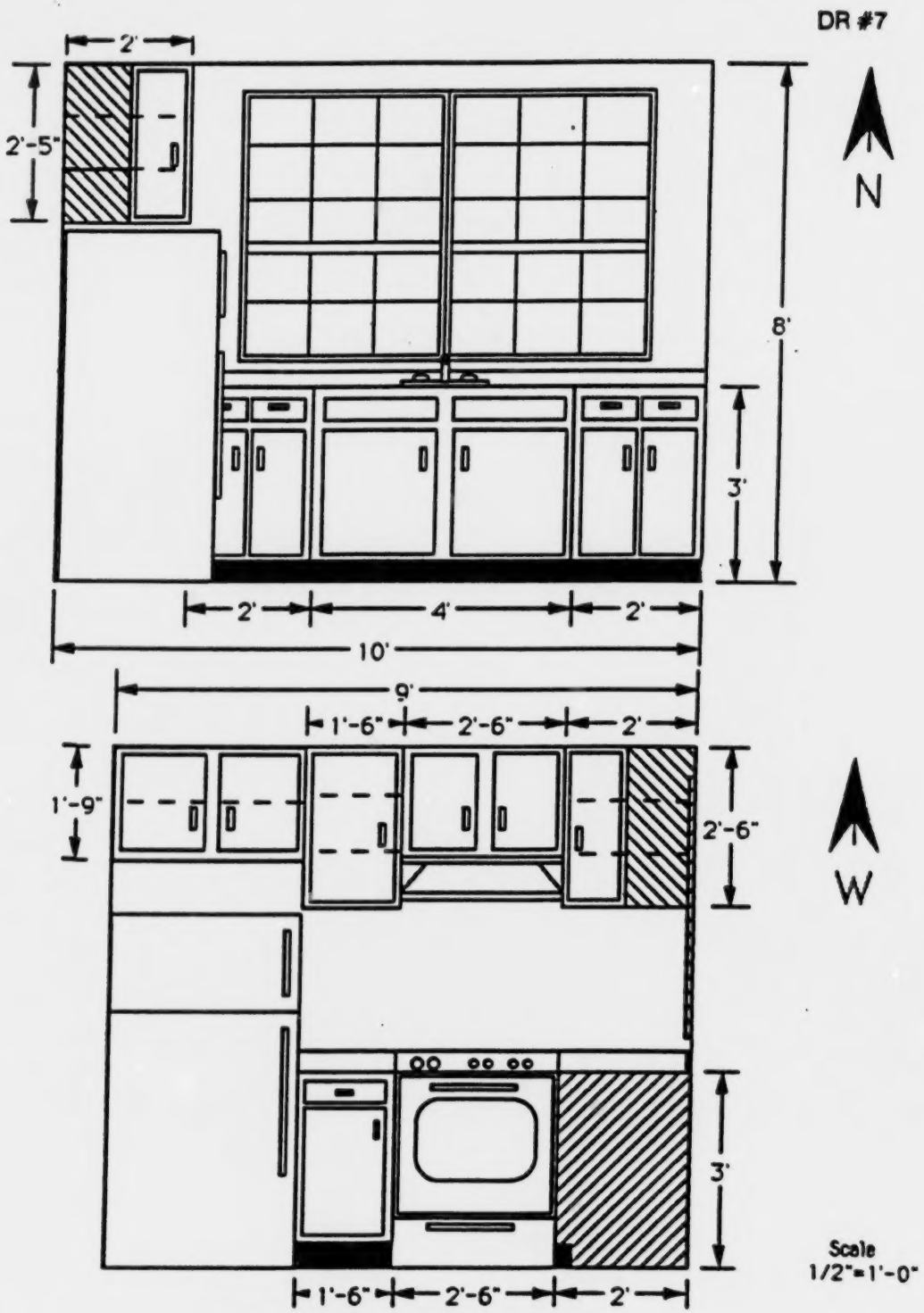
Left Elevation (east)

16-C



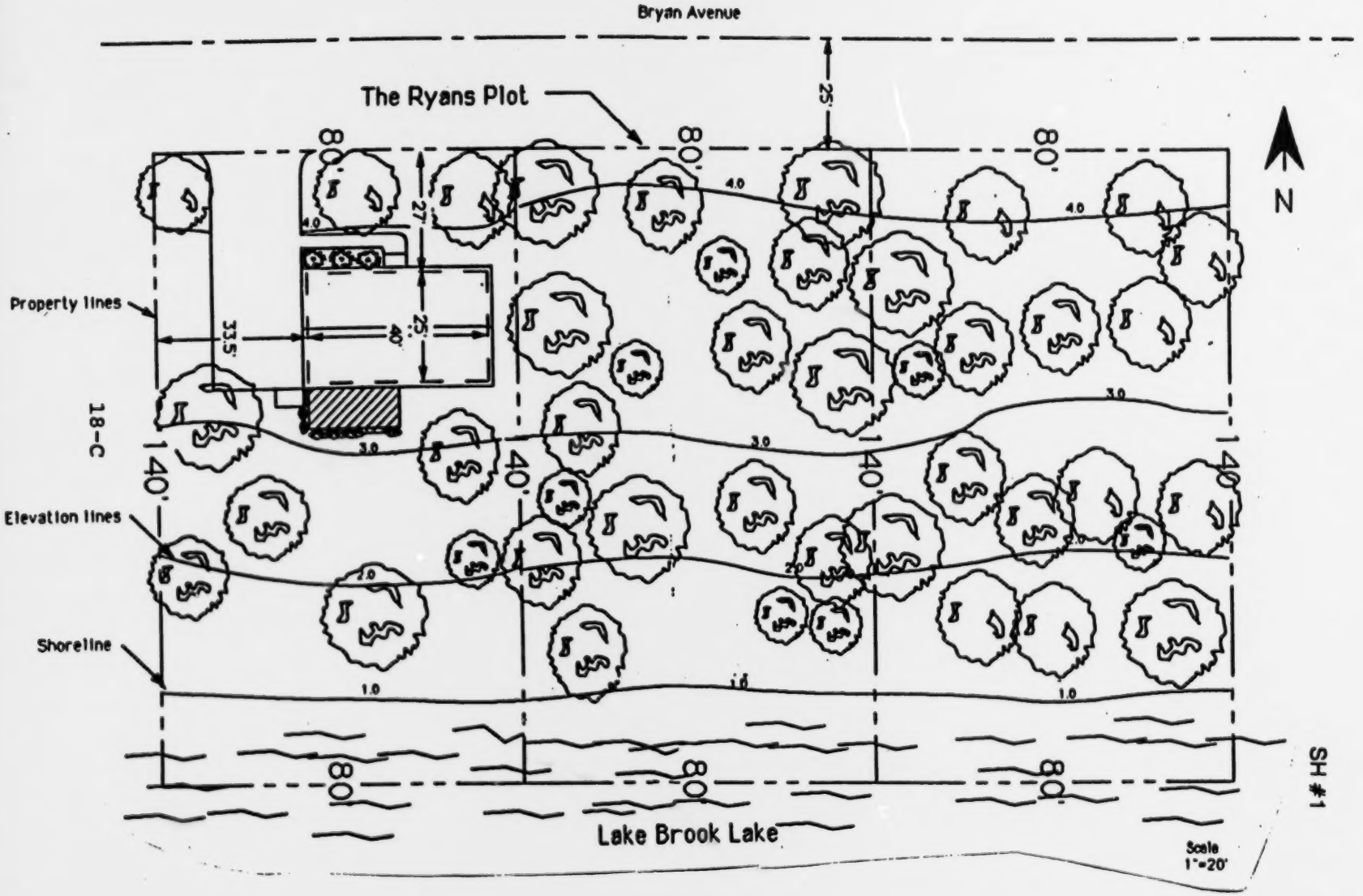
Right Elevation (west)

DR #6



Sample Detail Drawings

17-C


Bryan Avenue
The Ryans Plot
25'
80'
80'
80'
N
4.0
4.0
4.0
27'
Property lines
33.5'
40'
25'
18-C
3.0
3.0
3.0
140'
140'
140'
Elevation lines
2.0
2.0
Shoreline
1.0
1.0
1.0
80'
80'
80'
Lake Brook Lake
Scale
1"=20'
SH #1

PRESENTATION PEER EVALUATION FORM

Directions: After each design presentation, rate all of the presentation elements listed on the left on a scale from one to five.

Design Team Members: _____

_____

_____

_____

1	2	3	4	5
Very Poor	Poor	Average	Good	Excellent

Presentation Content:

- Addressed client wants and needs 1 2 3 4 5
- Met zoning laws, building codes, and local covenants 1 2 3 4 5
- The design's overall appearance 1 2 3 4 5
- The design is safe to construct and use 1 2 3 4 5
- The design stayed within the desired budget 1 2 3 4 5
- Working drawings communicated information clearly 1 2 3 4 5
- Presentation model represents the design 1 2 3 4 5

Presentation Skills:

- Use of visuals 1 2 3 4 5
- Communication skills (ability to answer questions) 1 2 3 4 5
- Eye contact 1 2 3 4 5

SITE PREPARATION AND SURVEYING

Introduction

Once a construction project has moved through the planning phase has been approved by the client, bidding and contracting are complete and the permits have been obtained, the next step is the preparation of the site. Site preparation involves the removal of objects from the building site like trees, shrubs, rocks, and existing structures (e.g., old buildings, homes, garages, road beds, bridges). In addition to the removal of objects, site preparation includes the leveling off of high spots and filling in of low spots. Depending on the condition of the site, several techniques can be used to prepare the site. Objects likes trees, shrubs, or rocks may have to be removed by cutting them out with saws or digging them up with bull dozers or backhoes. Some sites have large existing structures located on them. In order to remove them, the structure may need to be demolished. Demolishing destroys the structure in a safe manner. A large super structure in the middle of a city, for example, can be brought down safely by placing explosive charges at a strategic locations in the foundation system. If done correctly, the structure will collapse into itself without destroying or damaging surrounding buildings. Once destroyed, debris can be removed from the site by large trucks. Some materials like doors, windows, electrical wiring, and fixtures may be salvaged and used for other projects. Sometimes whole objects or structures can be salvaged (e.g., shrubs, trees, houses) and moved to a new location. A residential house, for example, in some cases can be lifted off its foundation using special jacks and be placed on wheels. Then the house can be pulled to another site where it is lowered onto a foundation and continue to be used.

Sites which are hilly or have sections that slope typicallyrequire the land to be leveled. A highway, for example, must be level or have low rising slopes. To accomplish this, land surrounding the site is either cut away or filled in. In order to clear and level the land, large pieces of earth moving equipment like bulldozers, power shovels, scrapers, trenchers, backhoes, front-end loaders, and trucks are used.

Once the site has been cleared and leveled, the exact location of the structure must be determined. This is commonly done by surveying. Surveying is a technique used to measure land. Surveyors use special pieces of equipment like transits, levels, leveling rods, and measuring tapes to measure the land's contour and features. Information gained through surveys can be used to create drawings or maps (e.g., plot plans, topographical map) and/or locate structures on a section of land.

This Technology Education Activity will allow students the opportunity to prepare and locate a building site.

Material and Supplies

- Site fixture (DR #1)
- Batter boards (DR #2)
- Plumb bob (Dr #2)

- Sample building layout (DR #3)
- The Ryans original plot plan (SH #1)
- Tree template (SH #2) (5 copies per group)
- Tree template (SH #3) (4 copies per group)
- Kite string
- Thumbtacks
- A scale or ruler
- Plot plan (NOTE: Students should use the plot plan they developed in the previous activity.)

Problem Statement

Lake Brook Construction Company has been contracted to build Mr. Ryan's summer home. One of the first phases of construction is to prepare the site. This includes clearing the site of trees and other obstacles. The next step is to locate the structure on the site. As a member of the construction team assigned to Mr. Ryan's building project, it is your job to clear the site and determine the exact location of the structure.

Activity Procedures

Clearing the Site

1. Before beginning, arrange the site to look like the plot shown on SH #1. This can be done by cutting out the tree templates found on SH #2 and #3. Using the Ryan's original plot plan (SH #1) as a guide, place each tree template onto the site fixture (DR #1). Be sure the trees are thumbtacked to keep the templates in place.

2. Obtain a copy of the plot plan for Mr. Ryan's new house. NOTE: Students should use the plot plan they developed in the previous activity.

3. Using your plot plan as a guide, locate the general building site. Once identified, remove the trees and other obstacles located near the site. NOTE: Because of the scale of this activity, some trees may be temporarily removed in order to complete other activities.

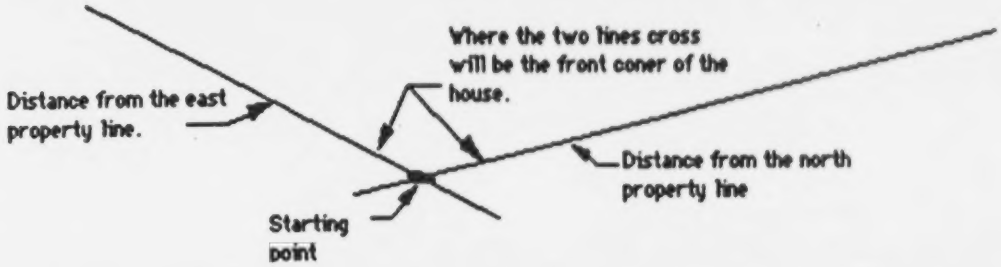
4. When all obstacles have been removed, spend some time smoothing and leveling the site.

Locating the Building Site

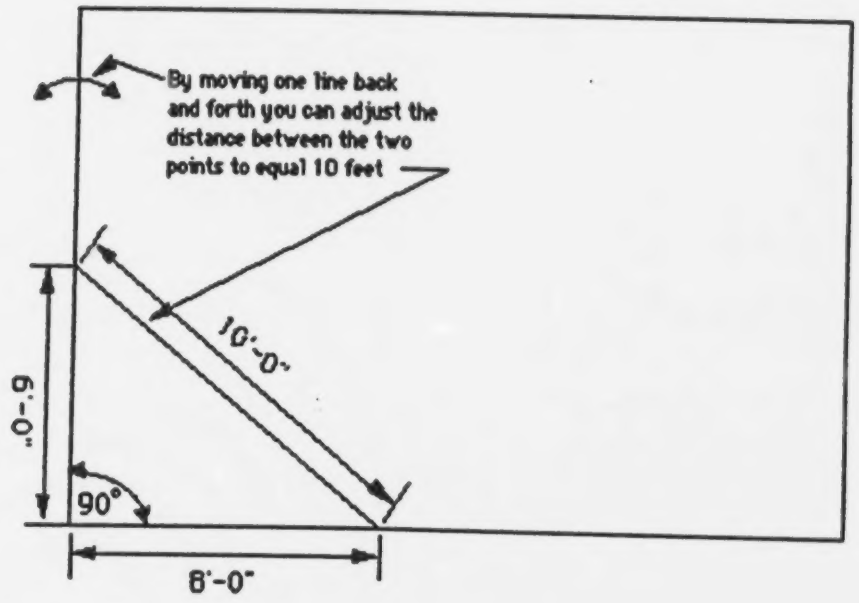
1. The next step is to determine the location of the structure on the site. In order to do this, you must locate a starting point. The starting point for this activity will be the front left corner of the house (looking from the north end of the site fixture). To locate this point on the site fixture, determine the distance from the north edge of the property line to the front edge of the house. NOTE: Remember to locate the distance from the edge of the house and not the edge of the roof. Using a scale or ruler, carefully measure from the north property line (the front inside edge of the site fixture) the distance indicated on your group's plot plan. Mark the location with a dot. Remember the site plan has been scaled down to 1/4" = 1'.

2. Repeat the measuring step for two other locations. Be sure to space the measurements apart. Then, use a straight edge and pencil to scribe a straight line through each dot.

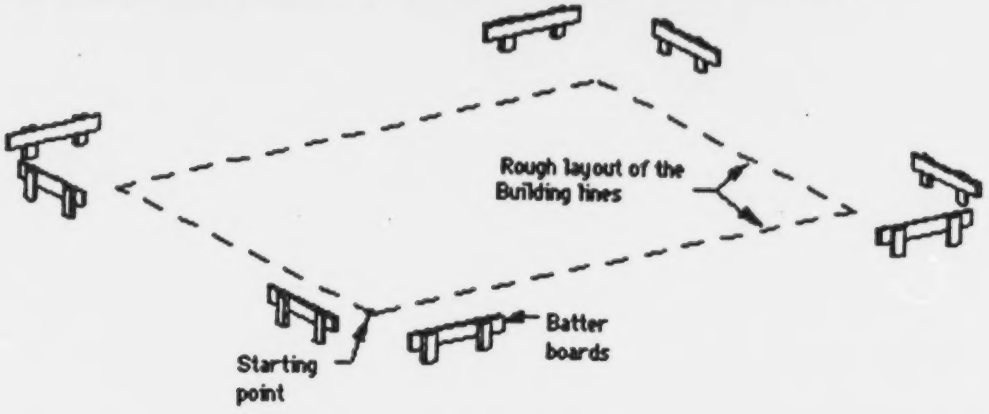
3. Next, use the plot plan to determine the distance between the east property line and the east side of the house. Using the process described above, measure and locate three dots. Extend a line through the three dots until it crosses the first line. Where the two lines cross will be the front left corner of the house (see illustration below).


Where the two lines cross will be the front corner of the house.
Distance from the east property line.
Distance from the north property line
Starting point

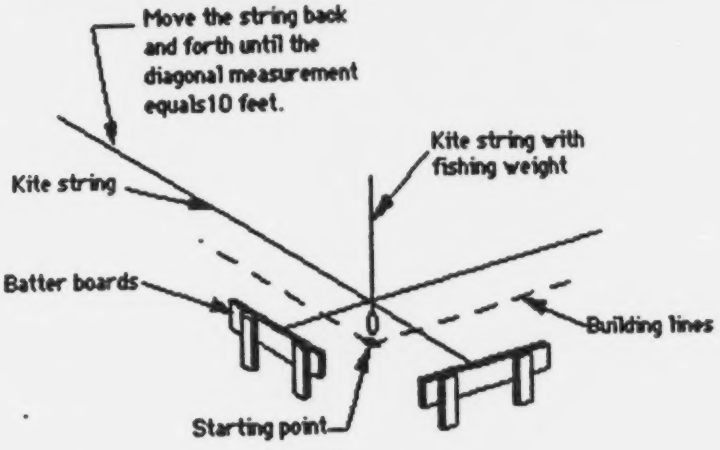
4. The next step is to locate and square the building lines. To do this a method called the 6-8-10 technique can be used. By measuring 6 feet along one side of structure and 8 feet along the other side, when the line connecting the two points equals 10 feet, the corner is at a 90 degree angle (see illustration below).

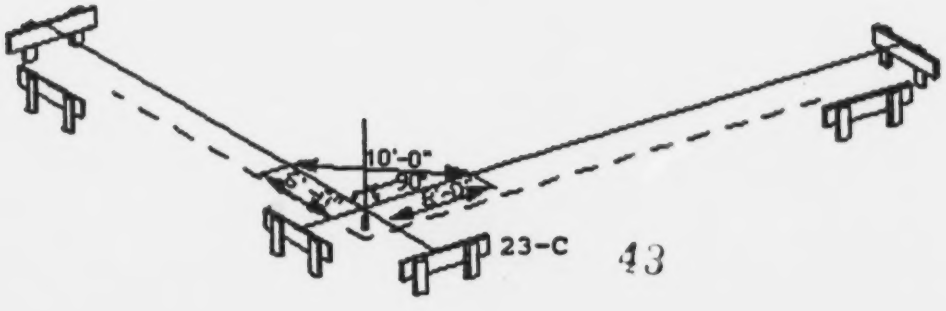


5. To lay out your site, batter boards must be used (DR #2). Batter boards are temporary pieces of wood used in the positioning and squaring process. String is attached to the batter boards in order to help visualize and mark the building lines. Using the illustration below as a guide, place two batter boards at each corner. The batter boards should be located approximately four feet from each corner (remember 1/4" = 1').



6. After the batter boards have been positioned, the next step is to square the structure. Using the string and the plumb bob (DR #2), square the starting point corner using the 6-8-10 method (as illustrated below).


Move the string back and forth until the diagonal measurement equals10 feet.
Kite string with fishing weight
Kite string
Batter boards
Building lines
Starting point



7. Once the starting point corner is square, measure and square the other corners. The finished shape should form a rectangle (see DR #3). Be sure the finished rectangle is the same size as the house. For example, if the house plan shows the structure should be 20 feet wide and 40 feet long, then the rectangle made by the string should be scaled to the same size.

SPECIAL NOTE: For those house designs that are not rectangular (e.g., L-shaped, T-shaped, U-shaped), divide the structure into several smaller rectangular shapes. Then, using the process described above square each rectangle.

Activity Analysis

1. Which of the following is NOT a part of site preparation.

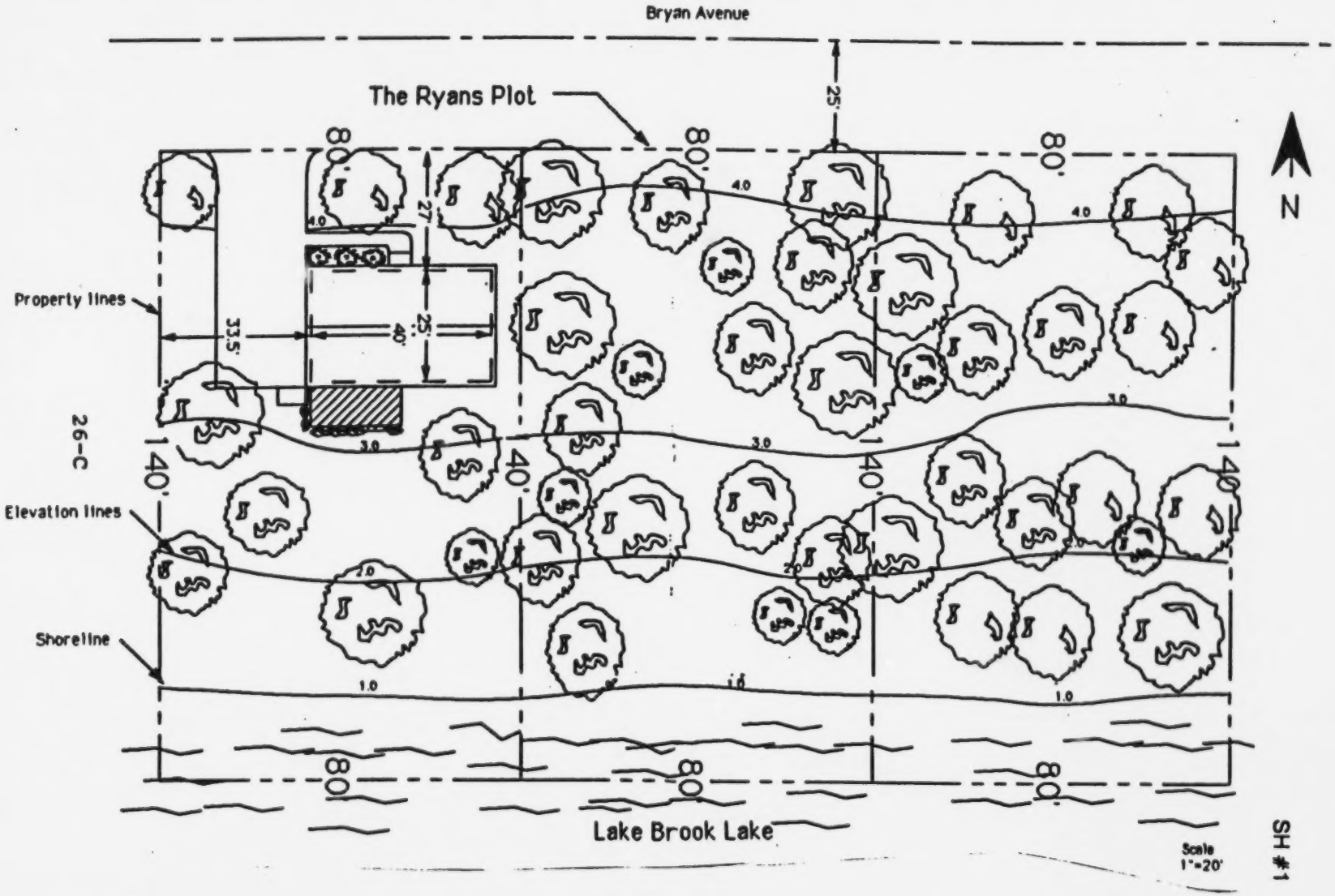
   a. Removal of objects and existing structures
   b. Salvaging usable materials
   c. Leveling off the building site
   d. Marking building lines

2. Surveyors use special equipment like _____ to measure the contour and features.

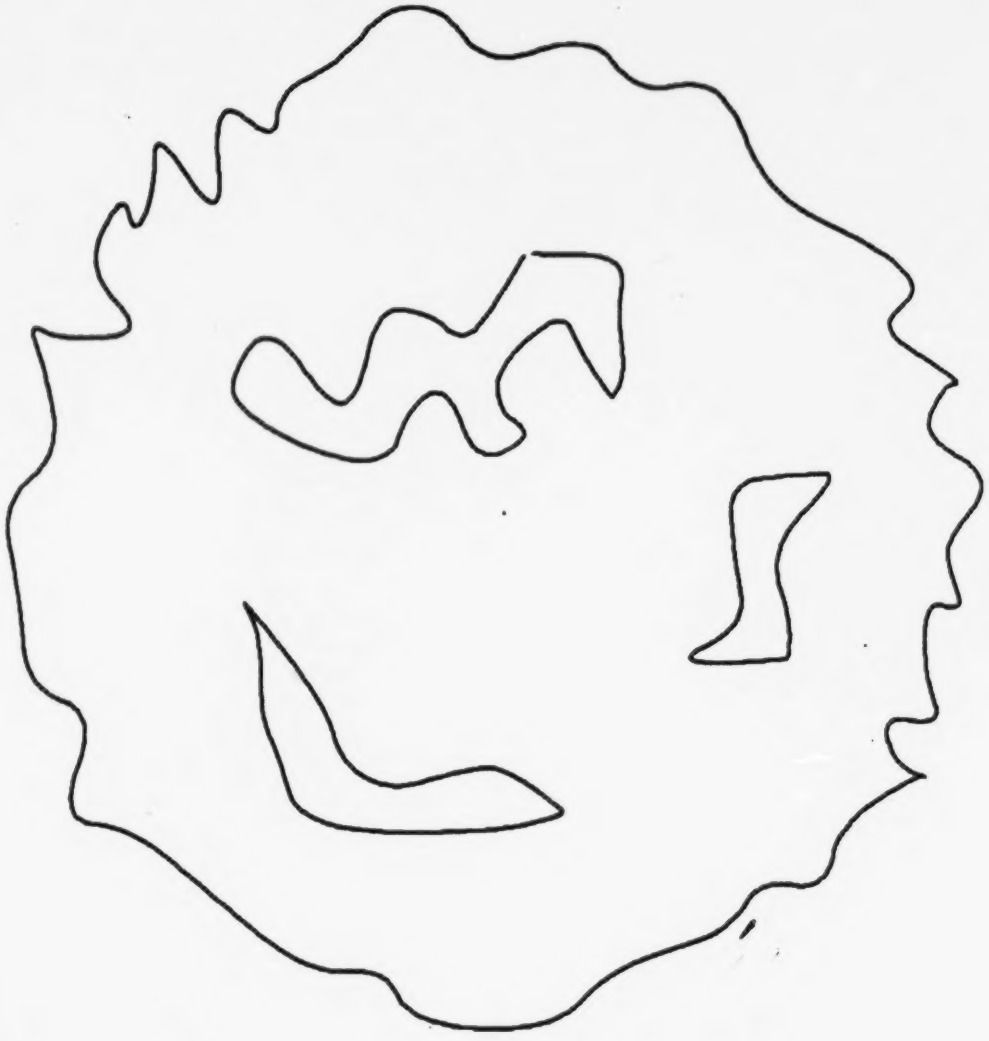
   a. Transits
   b. Bulldozers
   c. Floor plans
   d. Scrapers

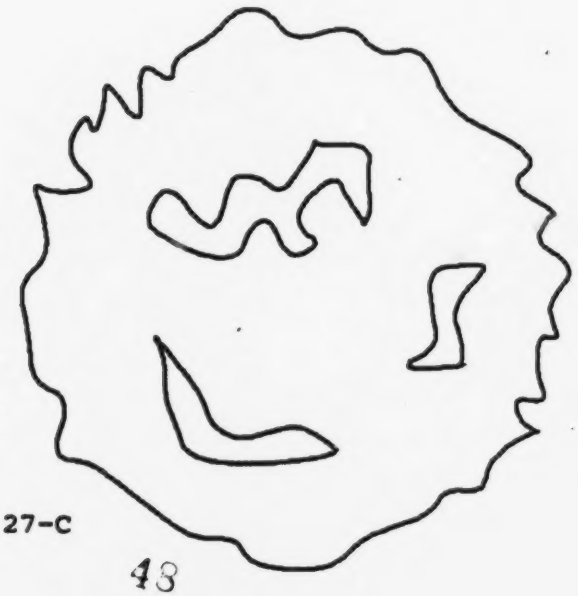
3. Information gathered from surveys are commonly used to develop _____ plans.

   a. Elevation
   b. Plot
   c. Detail
   d. Floor


Bryan Avenue
The Ryans Plot
25'
80'
80'
80'
N
Property lines
33.5'
27'
40'
25'
26-C
140'
140'
140'
Elevation lines
Shoreline
4.0
3.0
2.0
1.0
80'
80'
80'
Lake Brook Lake
Scale
1"=20'
SH #1

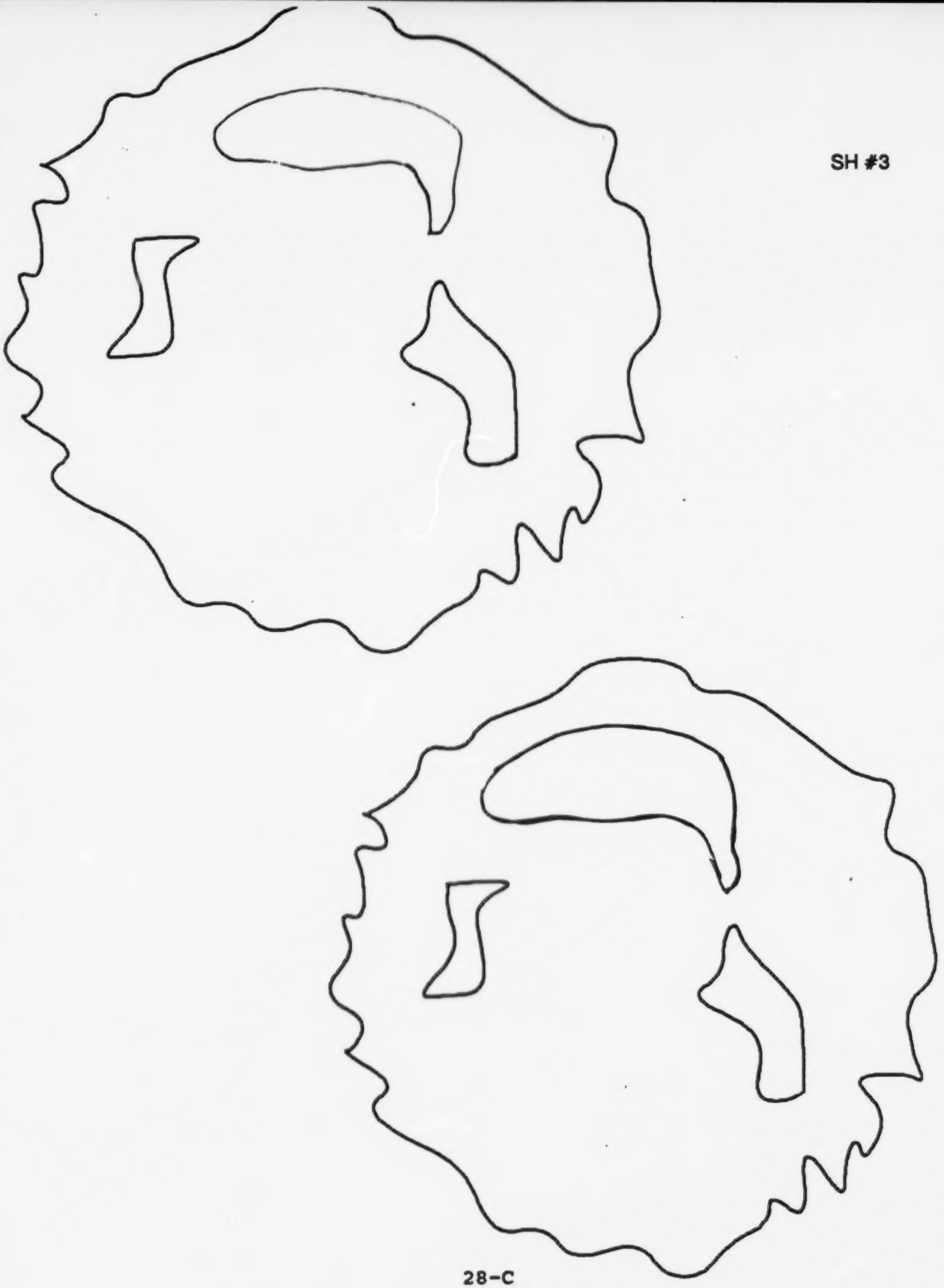
SH #2



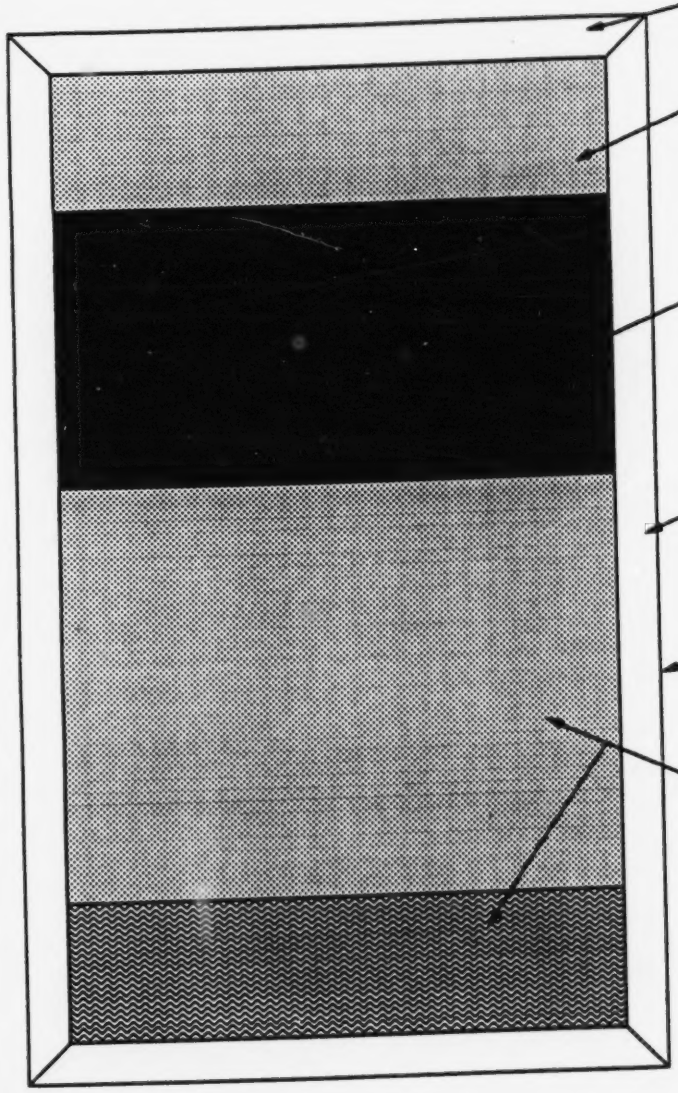


27-C

SH #3



28-C



Top and bottom- 1/2" x 1 1/2" x 23" pieces of wood

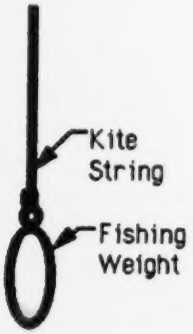
A piece of styrofoam or foam core 1/2" x 5" x 20" covered with green construction paper

Floral clay covering an area approximately 1/2" x 10" x 20"

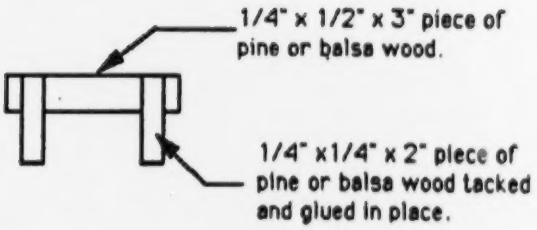
Sides- 1/2" x 1 1/2" x 38" pieces of wood

1/4" x 23"x 38" piece of masonite, nailed and glued to the bottom of the frame

A piece of styrofoam or foam core 1/2" x 20" x 20". An area approximately 15" x 20" should be covered with green construction paper (to represent grass) and an area approximately 5" x 20" should be covered with blue construction paper (to represent water).

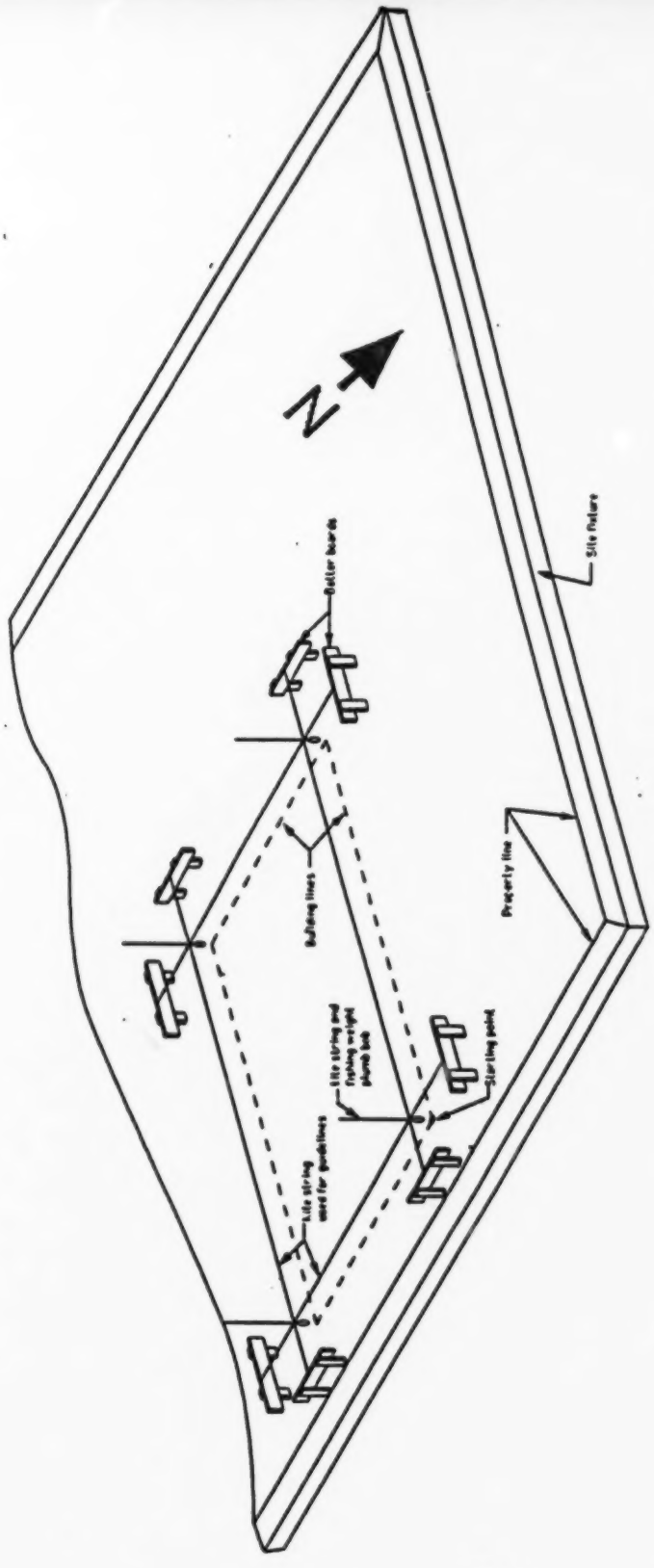


Sample Plumb Bob



Batter Board Details

DR #3

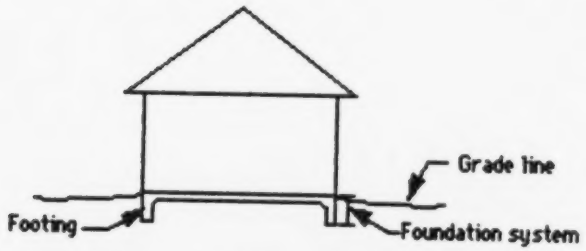

N
Site fixture
Batter boards
Property line
Building lines
Starting point

ERECTING STRUCTURES

Introduction

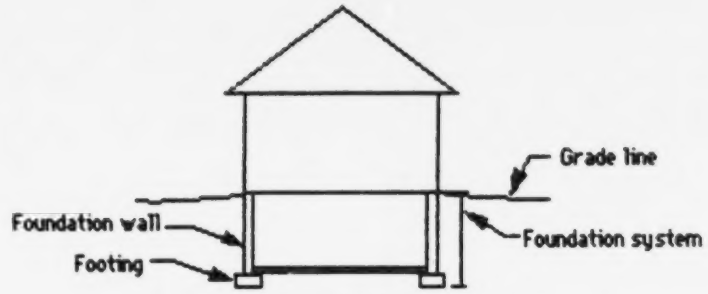
After the site has been cleared and the building lines located, the next step is to erect the structure. The erecting phase of the construction process can be divided into two parts 1) substructures and 2) superstructures. The substructure consists of a foundation system. The foundation system is used to support the weight of the main structure. The foundation system, through footings, should spread the weight of the structure over a large area. This keeps the structure from sinking into the ground. The Leaning Tower of Pisa, for example, is a structure that has a poor foundation system. Over the years the tower has sunk into the ground, thus causing it to lean. If not corrected, the tower will eventually fall over.

In order to distribute the weight of a structure, foundation systems use three types of footings: 1) slab, 2) spread, or 3) piles. The footing used depends on the structure's type and location. Small lightweight structures located in areas where the soil is soft or contains a lot of ground water, could be built on a slab foundation. Slab foundations rest on top or near the top of the soil (see illustrations below). This allows the slab to float. Slabs are also used in many warm climate areas. Structures are not affected by the ground shifting due to freezing and thawing in areas where the weather is warm year around.



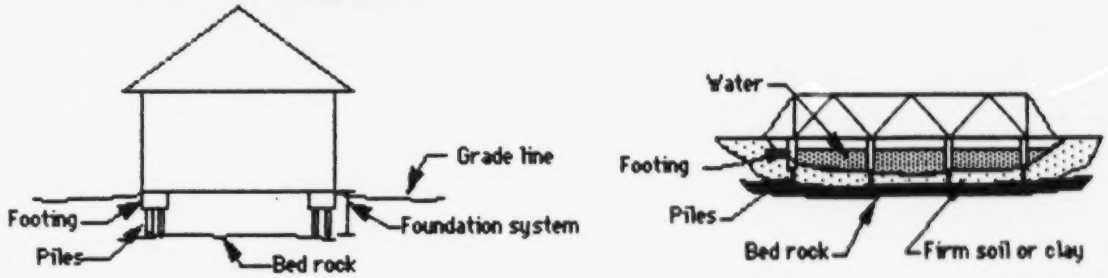
Simple Slab Foundation System

Larger, heavier structures, located in areas where the soil is hard or is near bed rock can be built on a spread footing. Spread footings place the weight of the structure on thick support walls (see illustration on next page. Wide footings under the support walls help distribute the weight of the structure. In cold climate areas, the footings must be located below the frost line in order to eliminate the effects of the ground shifting due to freezing and thawing. Structures with a basement or crawl space typically use a spread footing foundation system.



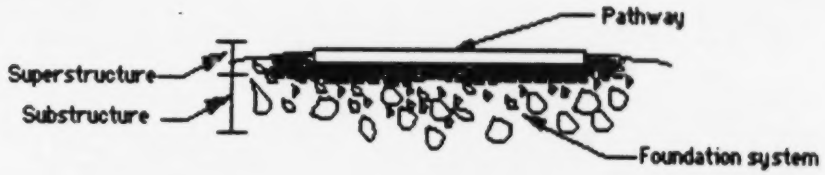
Simple Spread Foundation System

A third type, a pile footing, is used in locations where the soil is soft or wet. Bridges, for example, use piles to keep the structure from sinking and shifting. The piles are post driven into the ground until they hit solid soil or bedrock. Footings are then located on top of the piles (see illustration below). Since the piles are driven into solid soil or bedrock, the structure stays in place without moving or shifting.



Simple Pile Foundation Systems

Above the foundation system or substructure rests the main or superstructure. The superstructure provides shape to the structure. In most cases, superstructures rise above the ground (e.g., houses, factories, stadiums etc.). In some cases it is hard to determine the difference between the superstructure and substructure (e.g., roadway, dams, and tunnels). A highway, for example, looks like a slab foundation system without a superstructure. (see illustration below). Even so, underneath the road is a foundation system made of rock, dirt, and/or sand.



Highways and dams are known as mass superstructures. Mass superstructures are constructed by using large amounts of material such as dirt, concrete or stone. A dam, for example, may be built using dirt. The dirt is piled in layers. Each layer is compacted to make the structure solid. On the other hand, the Hoover Dam was built using large amounts of reinforced concrete in order to make it strong.

Other techniques like framing and solid wall construction are also used to erect and build superstructures. Residential structures are typically framed using wood joists, studs, and trusses. The joist, studs, and trusses are combined to form the structure's exterior walls, subfloors, interior partitions, rafters, and roof. Commercial structures commonly use steel pillars and beams to frame and shape the structure. The steel frame provides the load bearing strength needed to support tall multi-story structures.

Another technique used for some structures is called load bearing or solid wall construction. Thick solid reinforced concrete panels are used to support the structure. This type of construction uses either precast or site cast panels. The precast panels are prepared off-site. The panels are then brought to the site and set in place using large cranes. The site cast panels, as the names implies, are formed on-site. This eliminates the problem of transporting the large concrete panels. Once formed, the panels can be set in place.

Three superstructures growing in popularity include geodesic, pneumatic, and fabric structures. Geodesic structures use a series of triangles to frame the outside shape. The triangles provide the structure with a lot of compression strength. This means the weight of the structure is transferred to the outside walls, allowing the structure to be built with little or no interior supports. It allows the structure to have a large open floor plan, free of obstacles such as post, beams, or non-load bearing walls. Like geodesic domes, pneumatic or air supported structures need little or no interior support.

Pneumatic structures are supported by air pressure. This type of structure uses large fans to inflate the plastic or fabric covering or "skin" which gives the structure shape. Examples of air-supported structures include the Silver Dome in Detroit, Michigan and the Hoosier Dome in Indianapolis, Indiana. As long as the air pressure inside the structure is higher than the air pressure outside the structure, it will remain inflated. Fabric structures are tent-like structures that use large steel mast and cables to keep them supported. A fiberglass fabric that is light weight, air-tight, and waterproof is suspended using large steel masts. Once suspended, the fabric material is tightened and stretched using thick cables. Because the material is light weight, the structures can be made to span large distances. The Riyadh Stadium in Saudi Arabia has a diameter of approximately 1000 square feet and covers an area of 550,000 square feet. This is equivalent to 15 football fields put next to each other (Berger, 1988).

Other examples of fabric structures include Redbird Arena in Normal, Illinois, the Queeney Park Pavilion, in St. Louis, Missouri, and the Crown Center Square Pavilion, in Kansas City, Missouri.

This Technology Education Activity will introduce students to the concept of erecting a structure. During this activity students will create a simple slab footing and erect a superstructure for a scale model house.

Materials and Supplies

- Pine or balsa wood strips (1/4" x 1") cut to various lengths
- Mortar mix
- Chicken wire or similar material
- Right angle (tri-square or small 45 degree triangle)

- Bucket or plastic pan
- 4" putty knife
- Trowel
- 30 weight oil
- Screed (a piece of wood 3/4" x 3"x 12")
- Rags
- 10" x 12" sheets of 6 mil plastic
- A 3/8" - 1/2" dowel for settling the mortar mix
- Site fixture (same fixture used in the previous activity)
- Hot melt glue gun and glue sticks
- Poster board
- Toothpicks
- Rubber cement
- Floor Plan (the floor plan should have been created the first set of activities)
- Foam core (can be obtained at an art supply store) or cardboard
- Special glue for foam core
- A scale or ruler
- Utility knife and/or exacto knife
- Elevation (the elevations should have been created during the first set of activities)
- White electrical tape
- Straight pins

Problem Statement #1

After clearing the site and locating the building lines, the next step is to excavate the site and erect the structure. Your construction company has been selected to perform this task. Your construction crew, will be in charge of digging, framing, and pouring the foundation system. Once completed, your crew will erect the superstructure. The Ryans have decided to have the walls and roof system prefabricated off-site. The walls will come to the site in large completed wall panels. It will be your job to position and fasten the walls into place.

Activity Procedures

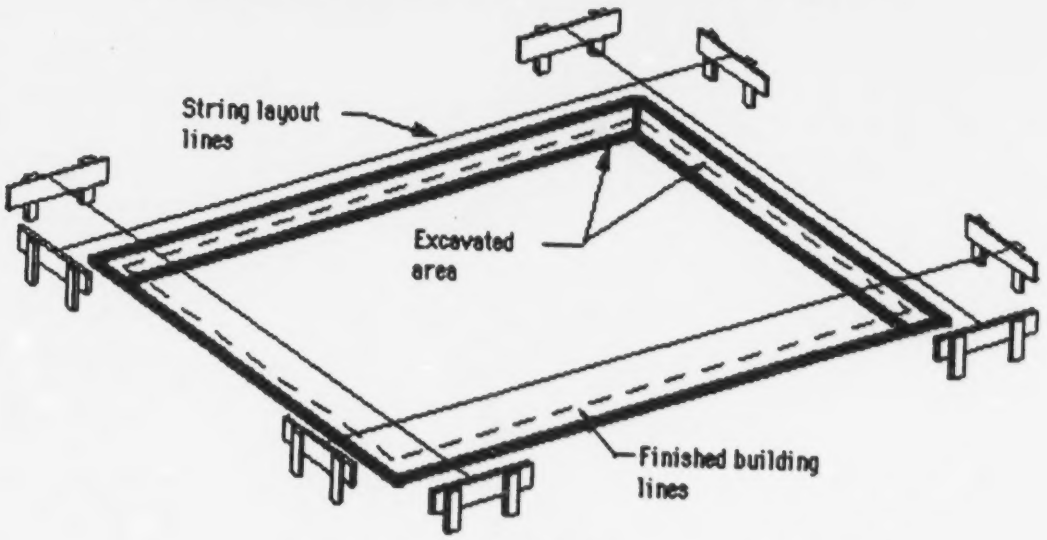
Excavating the Site

1. In the previous activity (Site Preparation), your construction crew cleared the site and located the building lines. The next step is to excavate the building area. (NOTE: Because of the scale of this activity, a simple solid floating slab will be used.)

2. Using the building lines as a guide, carefully remove the earth (clay) with the putty knife. (NOTE: In order to dig out the area, the string used to locate the building lines may need to be temporarily removed. It is important to note, the string must later be repositioned. The string will be used to check to see if the forms are square and positioned in the right place).The excavated area should be at least 1/2" to 3/4" larger than the lines representing the building lines. This will allow room for the wooden form. Wood forms are used to frame the shape of the foundation.

3. If the string locating the building lines was removed, take a few minutes to relocate it. If the structure is to be the proper size and square, it is very important the lines be positioned correctly. Refer to the previous activity if you have any questions in laying out the structure.

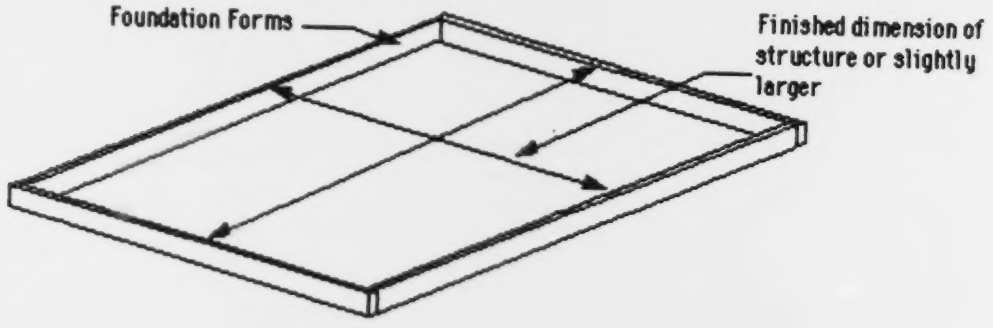
4. When completed, the site should look something like the illustration below. NOTE: The illustration shows a rectangular foundation. The shape may vary.



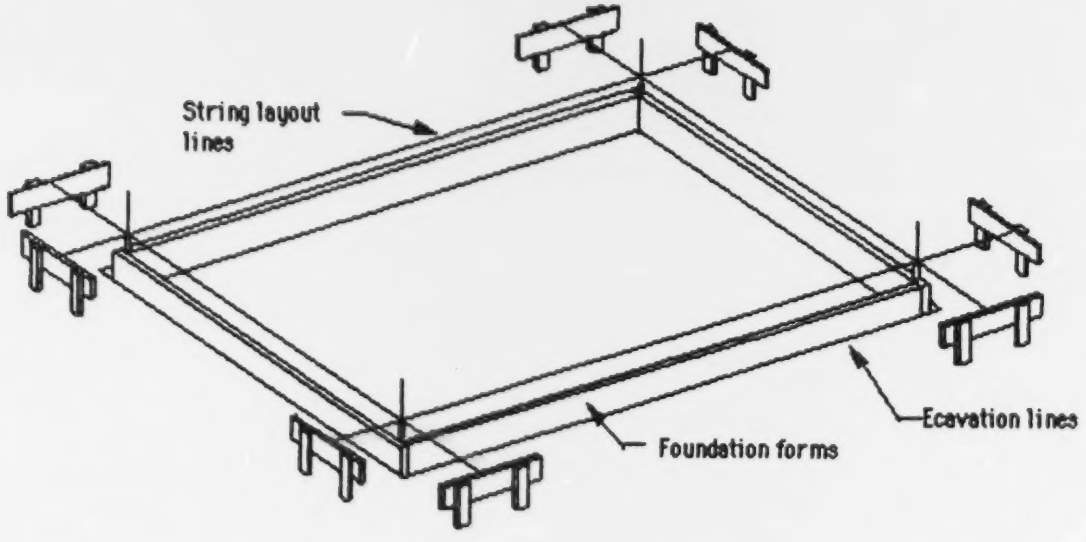
36-C

Creating a Foundation System

1. Once the site has been excavated, set and square the foundation forms. Using the 1/4" x 1" strips of wood, create a frame. Remember the inside measurement must be equal to the finished size of the structure (see illustration below). (NOTE: Forms built full scale will be a little bigger than the finished size. This is because the concrete will shrink when it dries. This may happen to a limited extent to your foundation.)



2. When the frame is the right size, position it into place. Using the string layout lines, the plumb bob, and a right angle (e.g., small 45 degree triangle, tri-square), place and square the forms into the excavated area. Be sure each corner of the forms is plumb with the string guidelines (see illustration below).



3. Use a hot melt glue gun and glue each corner of the forms. Small nails or straight pins may need to be used to keep the forms in place. Some excavated dirt (clay) can be placed around the outside of the forms to keep it from moving. Once positioned, oil should be applied with a rag to the inside of the forms. This will keep the mortar from sticking to the forms. Have the local building inspector (your instructor) check your work.

4. After the forms have been inspected, remove the string guidelines and batter boards.

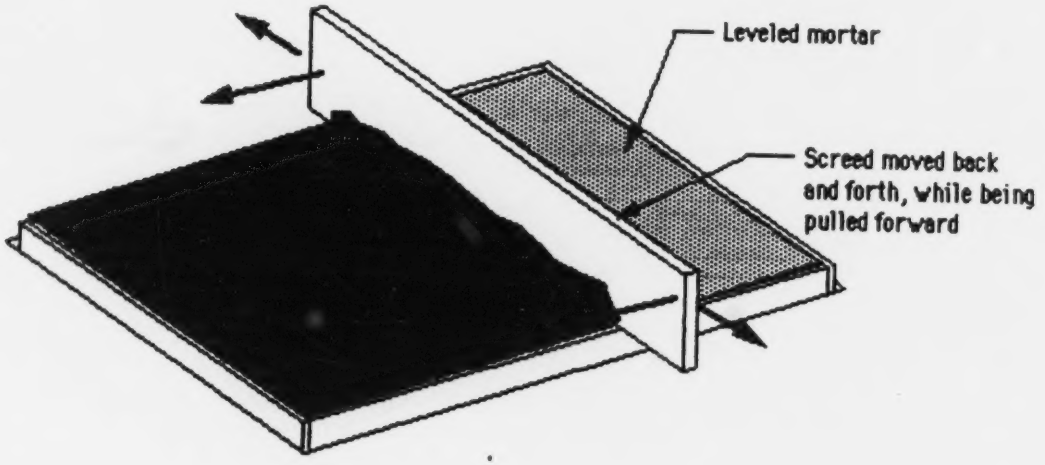
5. The next step is to prepare and pour the foundation. Begin by cutting a piece of wire mesh to match the shape of your foundation. The wire mesh will be used to reinforce the mortar mix. By reinforcing the mortar, the foundation will be less likely to crack if moved or shifted.

6. Place several small pieces of wood (approximately 1/2" x 1/2" x 1/2") around the bottom of the foundation. The wooden pieces will be used to keep the wire mesh off the bottom of the foundation when the mortar is poured into the forms. After the pieces of wood are in place, position the wire mesh in the foundation.

7. After receiving instructions and permission from your teacher, mix the mortar. It is very important not to make the mortar too runny. Have your instructor check your work before proceeding.

8. Once approved, carefully pour the mortar into the form. Be careful not to pour the mortar too fast. This will cause the wire mesh to collapse to the bottom of the forms. Use a rod and tap it up and down in the mortar mix. This helps settle the mortar around the reinforcing and removes air pockets.

9. Next, screed off the excess mortar (see illustration below).



10. As the mortar begins to set up, smooth the surface with a trowel. Then take a piece of plastic and cover the foundation. The plastic will keep the mortar from drying too quickly and cracking. When finished, thoroughly clean the equipment.

Problem Statement #2

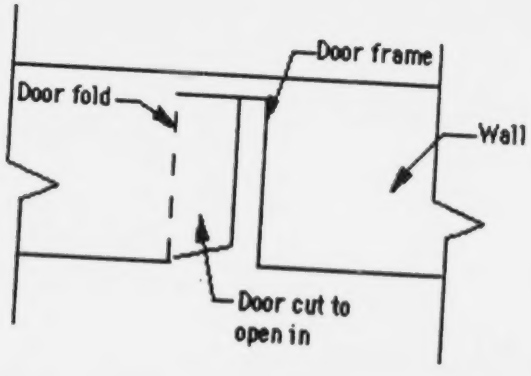
Erecting the Superstructure

The Ryan's house is being prefabricated off-site. The walls will come to the site as completed wall panels. As an employee of the Easy Fit Manufacturing Home Company, it is up to you and your crew to construct the wall panels for the Ryan's house. Once constructed, crews on-site will set the finished walls in place.

1. Once the mortar has set completely, the next step is to erect the structure. Begin by removing the plastic covering the foundation. Then using scissors, cut around the outside edge of a copy of your floor plan. NOTE: Make sure you use a copy of the floor plan and not the original.

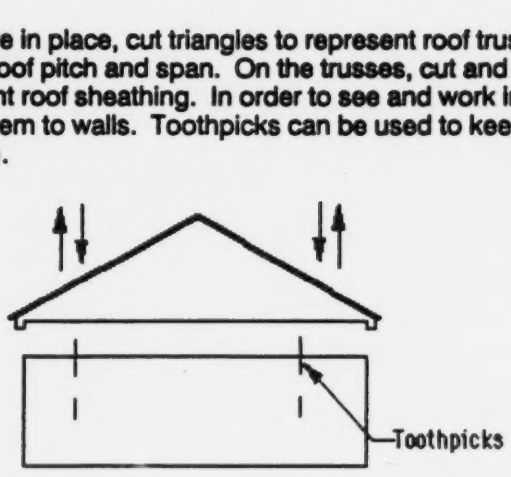
2. Use rubber cement and glue the floor plan to the top of the slab foundation. This will provide a guide for locating and placing the walls on the structure.

3. Using the floor plan as a guide, cut the building material (strips of 1/4" or 1/8" x 2" pieces foam core or cardboard) to match the length of the exterior walls. Once finished with the exterior walls, complete all the interior walls. (NOTE: In order to make the structure look more realistic, interior openings should be cut out. Cut the opening to the width indicated on the floor plan. The height should be approximately 6'-8" using a 1/4"=1'-0" scale. For openings with doors, cut along the top and one side [see illustration below]. Be sure to cut the side representing the door opening and not where the door hinges.) Do not cut exterior doors or windows. These will be installed later.



4. After all walls have been cut to size, the next step is to erect them on the site. Begin by carefully gluing the exterior walls to the foundation. The corners can be fastened using white electrical tape. Be sure the walls match the floor plan. If not, modify the walls as needed. Then match and glue the interior walls into place. Remember the openings in the walls should match those shown on the floor plan.

5. Once the walls are in place, cut triangles to represent roof trusses. The triangles should be cut to match roof pitch and span. On the trusses, cut and glue pieces of poster board to represent roof sheathing. In order to see and work inside the structure, do not glue the roof system to walls. Toothpicks can be used to keep the roof in place (see illustration below).



Activity Analysis

1. What type of footing is best suited for bridges?

   a. substructures
   b. slab
   c. spread
   d. pile

2. List three types of superstructures

   a. _____

   b. _____

   c. _____

3. Wooden frames used to keep concrete in place while it sets up are called.

   a. slab
   b. screed
   c. foundation
   d. forms

REFERENCES

Berger, H. (1988, October). Fabric structures change architecture. TIES, 19-25.

INSTALLING UTILITIES

Introduction

Most structures require support from various utility systems (plumbing, electrical, and climate control [heating and cooling]. Highways, for example, use plumbing systems to remove water during periods of rain, and electrical systems to provide lights near intersections and off-ramps. Some residential and commercial structures require not only plumbing and electrical systems, but also climate control systems.

A climate control system serves two purposes. First, it is used to carry warm and/or cool air from a furnace or air conditioner to various parts of the structure. Secondly, itprovides ventilation to the structure. Air is often moved through the structure using sheet metal pipes called ducts. Ducts are usually installed in the floors, walls, and ceilings. This keeps the duct work hidden from view once the structure is finished.

Like climate control systems, plumbing systems provide two services. First, plumbing is used to deliver fresh water. Fresh water is needed for cleaning, cooking, bathing and drinking. Various types of copper or plastic (PVC) pipes and fittings are used to deliver water. Typically, these pipes range from 1/2" to 3/4" in diameter. Secondly, plumbing is used to remove waste water and sewage. Waste water and sewage is removed using larger pipes. Like heating and cooling ducts, plumbing pipes are typically installed within the floors, walls, and ceilings.

Electrical systems are used to distribute electricity throughout the structure. Most structures typically have two types of electrical systems: power and communication. Power systems provide electricity for heating and cooling systems, appliances, and lighting. From a service box (this is a box connecting the structure to the main power line and the meter) cables or conduit are located through the floors, walls, and ceilings to electrical junction boxes. Junction boxes are connecting points for outlets, switches, and light fixtures. Communication systems provide the electricity for telephones, door bells, computers, and intercoms.

The process of installing utilities involves two stages. First, there is a rough-in stage which includes the installation of junction boxes, conduit, and service panels; water supply lines, shut off valves, and sewer lines; and duct work, furnaces, and air conditioners. Second, utility systems go through a finishing stage. The finishing stage includes the installation of light fixtures, cover plates, and electrical appliances; faucets, sinks, and dish washers; and vent covers, humidifiers, and thermostats. Typically, utilities are finished after the interior of the house has been finished.

Materials and Supplies

- (2) Lamp holders
- (2) 7.5 volt light bulbs
- (1) SPST slide switch
- (1) 9 volt battery
- bell wire (white and black)

- Terminal barrier strip (at least 4 post)
- Bolts, wing nuts, and washers
- Site fixture with erected structure
- Wiring layout (DR. # 1)
- Screw driver
- 1/16" drill bit and drill
- Exacto knife

Problem Statement

Your company, Tri Star Electrical Company, has been subcontracted to install the electrical system for the Ryan's home. The Ryan's have indicated they wanted an exterior light to illuminate the rear entrance of the house. It is up to you and your crew to install the light fixture, wire the switch, attach the service panel, and connect the system to the main power supply.

Activity Procedures

1. Obtain the materials listed above from your instructor.

2. Using the Ryan's electrical plan (created in the first set of activities), locate the service box. Once identified, mount the service box (terminal barrier) to the corresponding wall of your model. NOTE: because of the scale used for this activity, the service box may need to be relocated to a more convenient location.

3. Next, use the electrical plan to identify the location of the switch. Cut a piece of wire (black) long enough to reach from the service box to the switch. (NOTE: To make the finished model look less cluttered, the wire can be hidden inside the wall. This can be done by using a small drill bit (1/8") The bit can be used to drill a hole in the top of the wall down to a location near the service box. Then a hole can be made near the service box to link up with the first hole. The wire can be fed through the hole out the top of the wall. Once out of wall, the wire can be run along the top of the walls to a spot near the switch. White electrical tape can be used to keep the wire against the top of the wall. (The same procedures can be used to hide the wiring for the switch and light fixture.)

4. Attach the black wire to one of the post on the switch (DR. #1) and the other end to one of the terminals on the service box. (NOTE: Because of the scale of this activity, the wire may need to be soldered in place. If so, ask your instructor for assistance).

5. Cut another piece of black wire long enough to reach from the switch to the light fixture. Once cut, fasten the wire to the other post on the switch (DR #1).

6. Run the other end of the wire to the location of the light fixture (refer to the electrical plan). Using small bolts and wing nuts, fasten the switch to the wall.

7. Once the switch has been attached, connect the wire to one of the posts on the light fixture.

8. Next, cut a white wire long enough to reach from the service box to the light fixture. Connect one end of the wire to the service box and the other end to the second post on the light fixture (DR #1). Once connected, mount the fixture to the wall.

9. Finally, connect the service box to the main power supply (battery). The black wire should be hooked up to the positive terminal, and the white wire hooked up to the negative terminal (DR #1). Have the electrical inspector (your instructor) check your work before testing.

10. Test the circuit by turning the switch off and on. If the light goes off and on, then the circuit is good. If the light stays on all the time or fails to come on, recheck all the connections and try the test again.

Activity Analysis

1. List three types of utilities.

   a. _____

   b. _____

   c. _____

2. List two types of electrical systems.

   a. _____

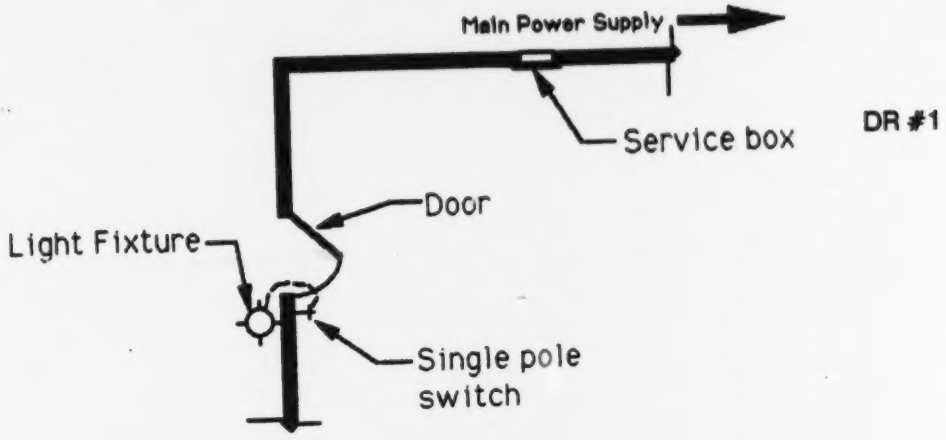
   b. _____

3. The installation of service boxes, duct work, and water supply lines, are examples of _____

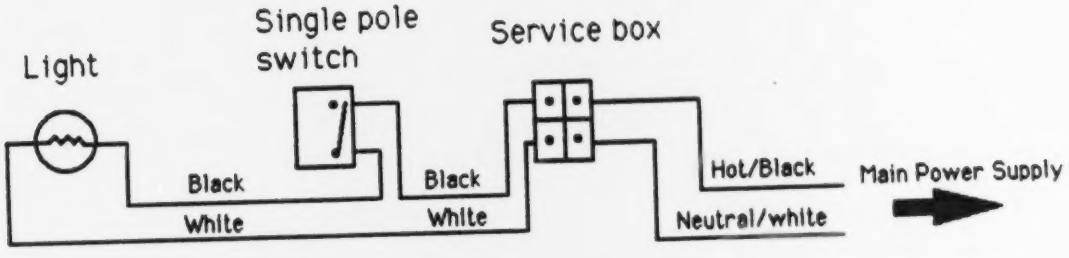
   a. Rough-in
   b. Finishing
   c. Communication systems

4. The installation of light fixtures, vent covers, and thermostats, are examples of _____

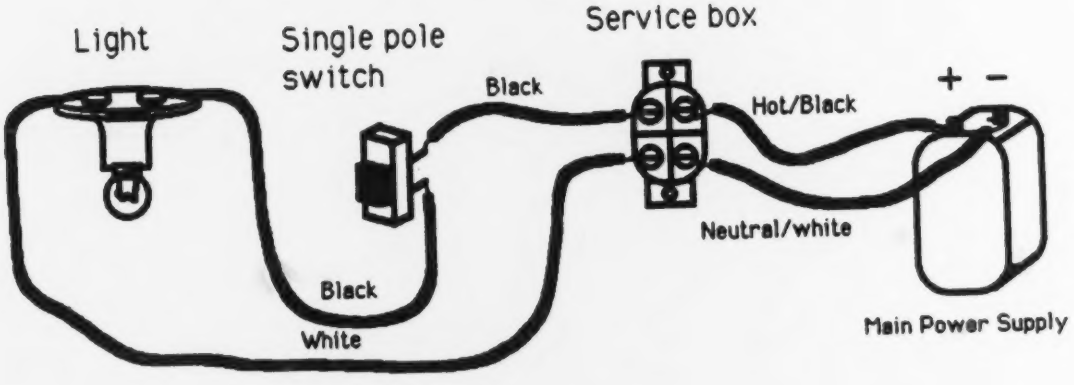
   a. Rough-in
   b. Finishing
   c. Communication systems



Blue Print Illustration



Schematic Diagram



Pictorial Illustration

ENCLOSING AND FINISHING

Introduction

Many structures such as homes, factories, shopping malls, and athletic stadiums must be enclosed. Structures are enclosed for a number of reasons. First, enclosing protects people and property from intruders and weather. Secondly, enclosing adds style and character to the appearance of the structure. For example, plaster, black rot iron, and red tile shingles, can be used to give the exterior of a house a Spanish look. Finally, it provides privacy.

Enclosing the exterior involves covering roofs and walls. Many structures use some type of sheathing to enclose roofs and walls. Roof sheathing is commonly made of plywood or wafer board. Wall sheathing is made from plywood, wafer board, fiber board, gypsum, or insulation board. Once enclosed, the sheathing is covered with various finishing materials. Roofs are finished using materials like asphalt, fiberglass, wood, slate, or ceramic tile shingles; corrugated metal or fiberglass panels; or plastic, vinyl or fabric sheets. A residential house, for example, may be covered with asphalt or wood shake shingles, while, an air-supported stadiums may be covered with fabric or vinyl sheets. Like the roof, exterior walls must be covered and finished. Exterior walls can be finished using materials like brick, stone, concrete, metal, glass, wood, plaster, aluminum, and vinyl. The type of materials used depends on the structure. The Gateway Arch in St. Louis, for example, is covered with large stainless steel metal panels. The exterior walls of a residential structure, on the other hand, may be covered with brick, wood panels, or vinyl siding.

Exterior openings for doors, windows, and skylights are another part of a structure's exterior that must be enclosed. Exterior openings provide a connection between the inside and outside of the structure. Windows provide access to natural light, heat, and ventilation, while doors provide access to the inside and outside of the structure. Like exterior coverings, doors and windows can add style and character to the appearance of the structure.

As the exterior is covered and utility systems installed, the structure's interior walls, ceilings, and floors can be enclosed and finished. A material called drywall (gypsum board) is the most commonly used material to cover interior walls and ceilings. Drywall comes in large sheets. The sheets are attached to the wall with glue, screws, and/or nails. Once in place, nails and seams are covered and smoothed. When finished, the surface can be painted or wall papered. Other materials like wood paneling, plaster, stone, brick, and ceramic tile are also used to enclose and finish interior walls.

Once the walls have been enclosed and finished, floor coverings can be applied. As the structure is built, floor joists are enclosed with a subfloor. Subfloors are usually made of sheets of plywood, providing a smooth solid surface to attach the finish flooring. Finished floor coverings include materials like ceramic tile, stone, brick, concrete, wood, vinyl, and carpeting.

After the structure has been enclosed and coverings applied, the next step is add the final touches to the structure. This stage is commonly referred to as finishing. Finishing involves trimming and installing accessories inside and outside the structure. Trimming includes fastening wood or plastic moldings around doors and windows and along floors and ceilings. The trim helps cover nails and cracks in places where walls, floors, ceiling, and corners meet.

Accessories in a structure may vary. Inside a residential structure, for example, there might be accessories for the kitchen (e.g., cabinets, faucets, shelving, light fixtures), bath (e.g., plumbing fixtures, medicine cabinets, electrical fixtures) and garage (e.g., electric door opener, attic steps, shelving). Outside a residential structure, accessories might include guttering, shutters, exterior light fixtures, and storm doors. Accessories for a major highway project may include stripping the pavement and erecting traffic signs.

Finishing does not stop with the structure. The site must also be finished, involving three activities. First, all pathways (e.g., sidewalks, driveways, parking lots) must be located and constructed. Secondly, the area must be landscaped, including planting trees, bushes, and shrubs; planting grass or laying sod; and building retaining walls, decks, and fences. Finally, the site must be picked up and all scrap building materials removed.

Once the site structure is finished, the last step is to transfer the project from the contractor to the owner. Before being transferred, the project must pass a series of final inspections. Inspectors check the structure to insure the project was built according to the original specifications. After the project has passed all inspections, bills are paid and releases signed. A release insures that all the people who work on the structure were paid. When all legal matters have been cleared, the owner makes the final payment and becomes responsible for the project.

Materials and Supplies

- Light gray, brown, and black construction paper
- Plain paper
- Various architectural landscaping templates
- Sample exterior coverings (SH #1-#4)
- Ruler or scale
- Scissors
- Rubber cement
- Traditional or computer-aided drafting equipment

Problem Statement

As the project moves into its final stages, both the site and structure must be finished. Two groups have been contracted to finish the Ryan's project: one group installing the pathways and landscaping, the second finishing the exterior, including applying finished covering to exterior walls, roof, and openings.

Activity Procedures

Begin by dividing into two groups. Group one will finish the site, while group two finishes the structure.

Procedures for Group One:

1. Using the Ryan's plot plan as a guide, identify the location of any sidewalks or driveways.

2. Then, using scissors and construction paper (gray for concrete and black for asphalt), measure and cut the paper to the desired shape. Be sure to make the shape according to scale (1/4" = 1').

3. Once cut, locate and fasten the pathways in place. Rubber cement can be used to attach the paper to the site fixture.

4. The next step is to construct any decks or patios. Once again refer to the plot plan. Identify the location and size of any decks or patios.

5. Using construction paper (brown for wood and gray for concrete) and scissors, cut the paper to the desired shape.

6. Once cut, use rubber cement to fasten the paper to the site fixture.

7. The last step is to landscape the site. Using the plot plan as a guide, identify areas to be landscaped.

8. Using tree and bush templates (SH #1), cut and position the plants where needed. (NOTE: The templates found on SH #1 only represent a sampling of possible landscape shapes. This activity can be enhanced with the use of various architectural landscape templates or a simple CAD program).

9. When finished, the site fixture should look like the Ryan's plot plan.

Procedures for Group Two:

1. Using the elevations as guide, determine the exterior covering used for the roof. Then, using the sample roof coverings found on SH #2 cut and paste the covering to the roof. In order to cover the entire roof, several copies may be required. (NOTE: This activity can be enhanced by reproducing the Student Handouts on various colored paper. This will allow students to add color to their design. The same procedure can be used in the steps as follows).

2. Next, use the elevations and determine the coverings used for the exterior walls. Once determined, select the appropriate covering from the samples found on SH #3 through SH #4. (NOTE: Notice the handouts only represent just a few possible exterior coverings. Other coverings can be made with architectural exterior surface templates or a simple CAD program).

3. After the appropriate covering has been selected, cut the material to the right size and glue it to the exterior walls. Be sure to take your time to neatly place the covering.

4. The next step is to enclose the exterior openings. Since, there are so many possible window and door styles, shapes, and sizes, each construction team will have to create elevation drawings to represent their design. Using traditional or computer-aided drafting techniques, make a scaled drawing for each exterior door and window. Refer to your elevation and floor plan drawings for the size and shape of each opening.

5. Once drawn, use your floor plan to carefully locate and position each door and window. Using rubber cement, glue them into place. When finished, the exterior of the structure should look like the elevations.

Activity Analysis

1. Discuss why structures are enclosed.

_____

_____

_____

2. What part of a structure connect the inside with the outside?

a. Roofs
b. Pathways
c. Exterior openings
d. Exterior walls

3. Which of the following are NOT part of the finishing stage of a construction project?

a. Trimming doors and windows
b. Installing gutters
c. Planting trees, bushes, and grass
d. Installing windows

4. List and discuss three activities involved with finishing the site.

a. _____

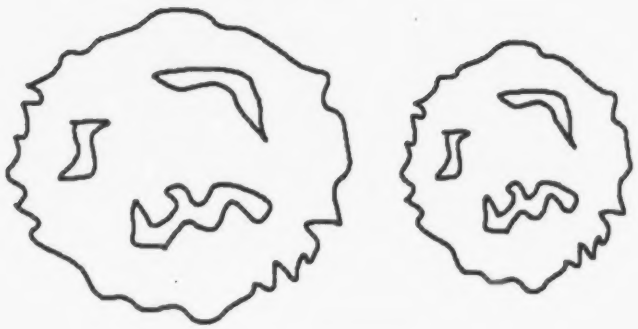
_____

b. _____

_____

c. _____

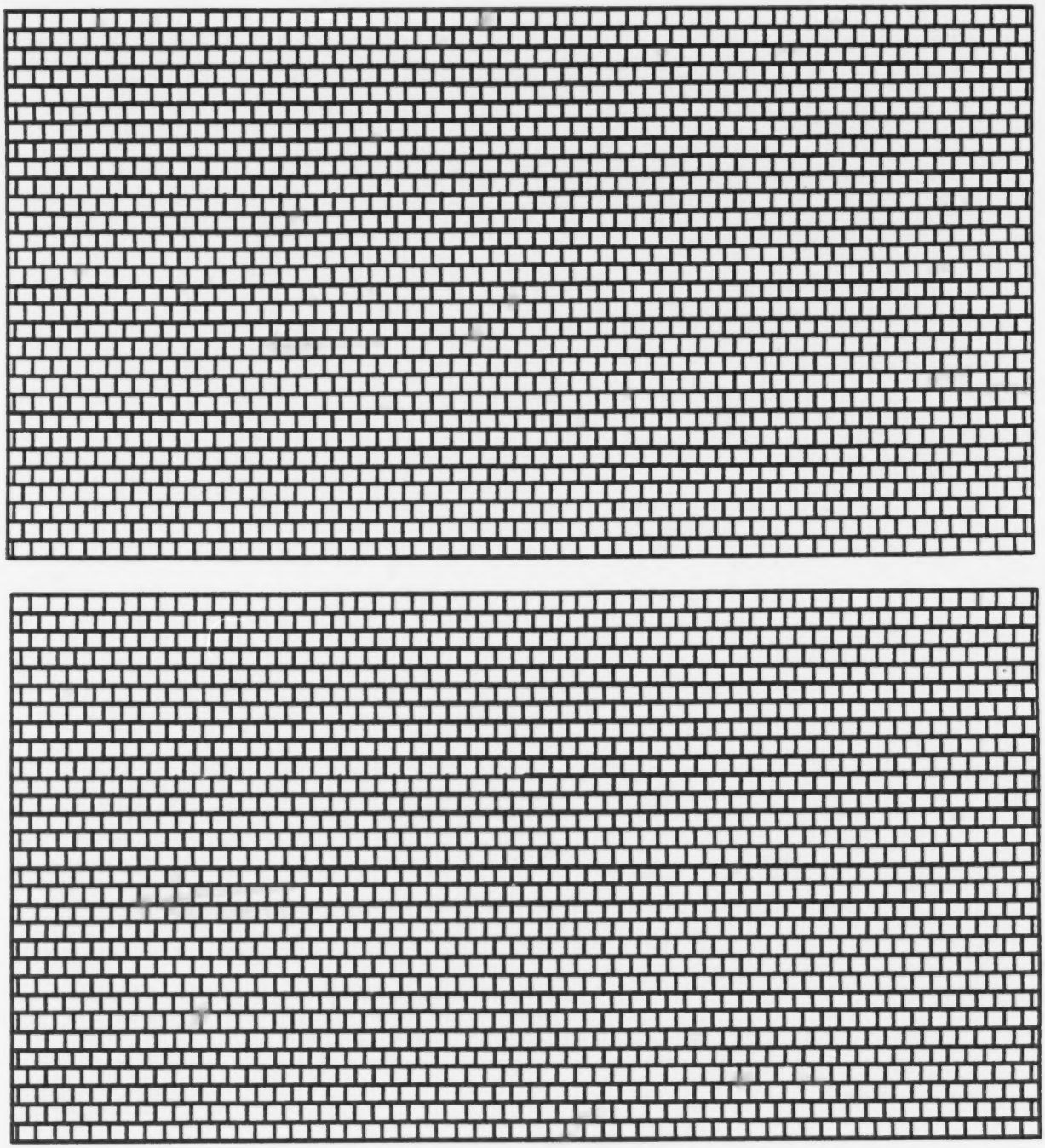
_____



TREES

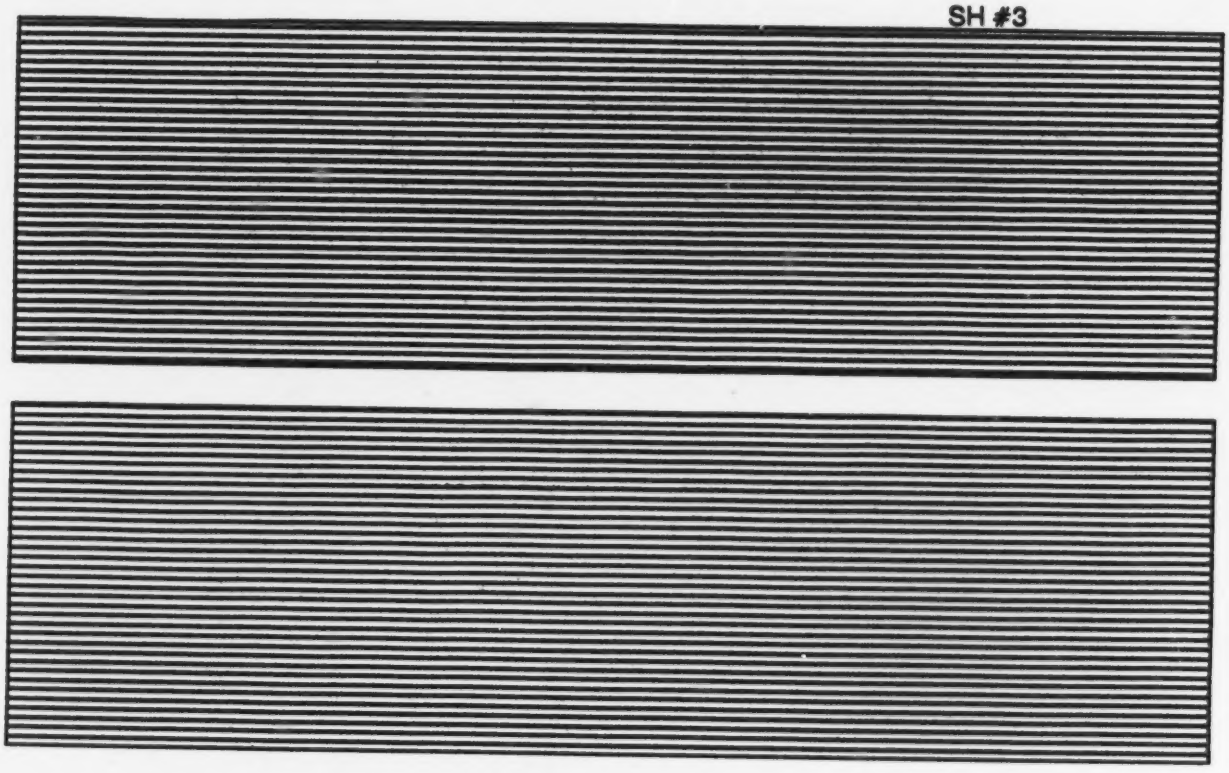
BUSHES

SH #2

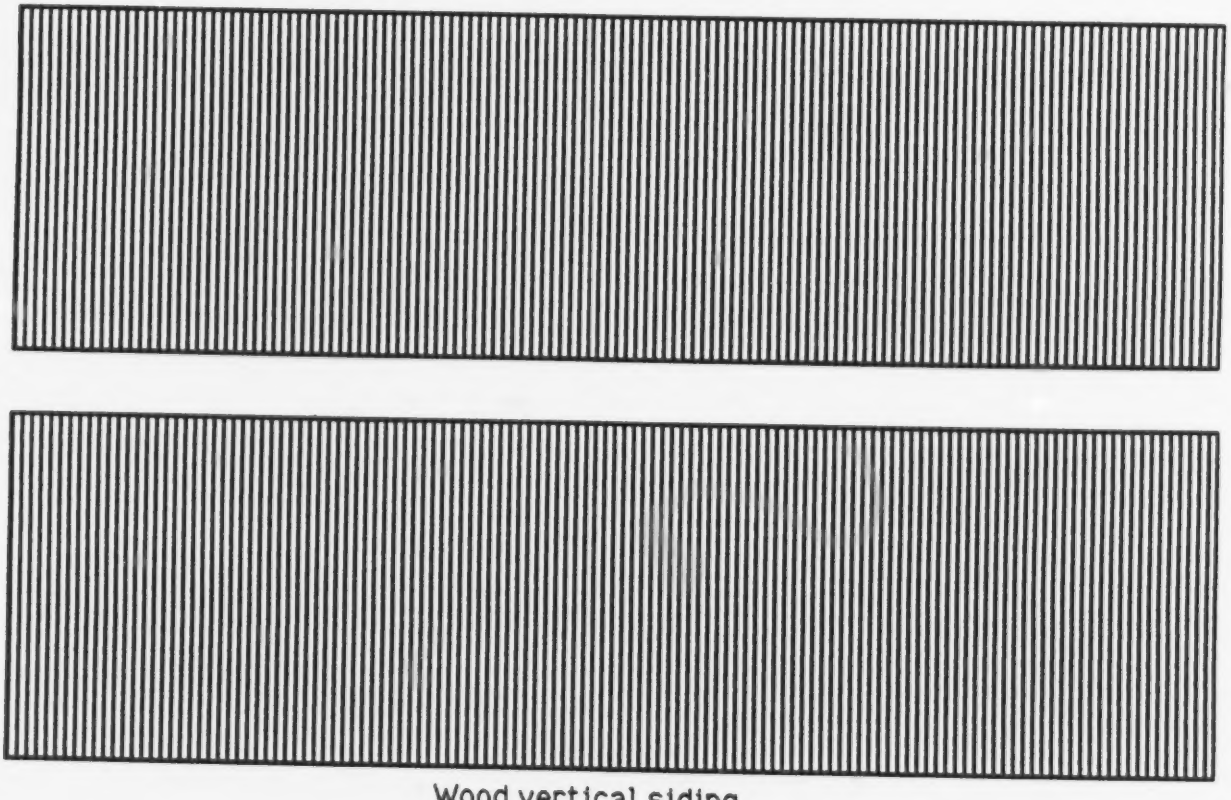


Asphalt and Wood Shingles

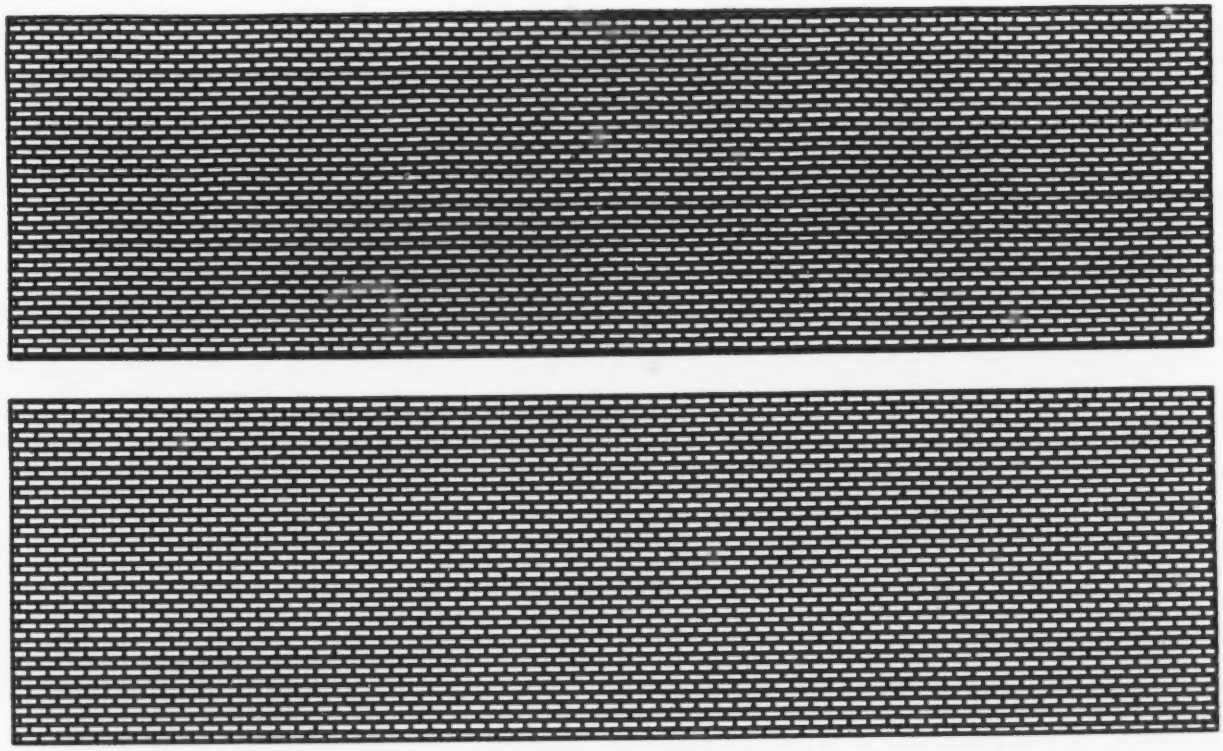
50-C



Wood Horizontal siding



Wood vertical siding



Brick

MANUFACTURING

MANUFACTURING SYSTEMS

Suggested Learning Objectives

Upon completion of the manufacturing systems unit, students will be able to:

A. Define and properly use common manufacturing **terminology** like automation, just-in-time manufacturing, statistical quality control, participatory management, group technology, and computer integrated manufacturing.

B. Identify basic **applications** for manufacturing technology including things like building automobiles, making electronic components, and producing food products.

C. Identify basic natural, human, material, financial, technological, and informational **resources** used in manufacturing processes and enterprises.

D. Describe the major **processes** used in the manufacturing products, including researching, developing, designing, engineering, planning, tooling, scheduling, expediting, selling, and distributing.

E. Describe the social and environmental **impacts** associated with manufacturing activities including displacement of workers, quality of work life, air and water pollution, waste disposal, and enhancing the quality of life. SC2

F. Describe the major milestones in the **history** and evolution of manufacturing including the establishment of cottage industries; introduction of interchangeable parts and Henry Ford's assembly line technique; and the development of computer-aided manufacturing processes. SS2

G. Identify and evaluate **career** opportunities in manufacturing (e.g., quality control technician, designer, industrial engineering) based on interests, talents, and career expectations.

H. Identify potential **safety** hazards, establish guidelines for safe behavior, and adhere to common safety practices when around or participating in manufacturing activities. PH3

I. Describe the role of research, development, and engineering in the manufacturing systems including identifying problems, gathering information, developing preliminary designs, selecting and refining designs, specifying designs, building and testing prototypes, and presenting designs to management.

J. Describe the role of industrial relationships within a manufacturing enterprise including maintaining communications; safety standards; and labor, public, and government relations.

K. Describe the role of marketing in the manufacturing system including market research, packaging goods, selling products, and distributing finished goods.

L. Evaluate custom, intermittent, and continuous manufacturing techniques for a given product based on equipment, human resources, materials, cost, quantity, and time considerations.

M. Apply basic mathematical concepts to do things like determine profit, compute quality control standards, estimate materials, and compile market research data.

N. Describe and forecast the implications of innovative manufacturing technologies like CAD, CAM, JIT, CIM, DNC, AGV, ASRS, and FMS on a manufacturer's work force, profit potential, product quality, efficiency, and competitiveness. SC2

O. Establish a student enterprise that has an identity, has an organizational structure, researches and develops a product, designs and implements a product system, markets the product, and handles financial affairs. SS1

P. Use common tools, materials, and techniques to perform manufacturing processes like making mock-ups, fabricating simple jigs and fixtures, and packaging products. PH6

Q. Discriminate between pure and applied research; custom, intermittent, and continuous manufacturing techniques; and proprietorships, partnerships, and corporations.

Suggested Learning Experiences

1. Introduce students to establishing a manufacturing enterprise. Using traditional graphics and computer-aided design tools, have each student identify, design, and propose a name and logo for their student enterprise. Ask students to evaluate each proposal and select the best five. Using criteria like appearance, readability, and appropriateness, have students select the best proposal. Discuss the importance of a strong company identity and how it effects profit. Have the students compare their logo design with those of other companies in their community.

2. Introduce students to the management structures used to organize manufacturing enterprises. Using materials like poster board, computer-aided graphics, and/or large sheets of paper, have students develop an organizational chart for their student enterprise. Include and fill positions for corporate officers, managers, and/or workers. Have the students discuss how the division of labor effects communication, efficiency, and profit in a manufacturing enterprise.

3. Discuss how enterprises raise capital to finance their manufacturing process. Using traditional and computer-aided graphic arts tools, have the students design and reproduce a stock certificate. Have students sell the stock to raise money for their student enterprise. The stock certificates should include things like the name of the company, the date of sale, the number of shares represented, an identification number, the value of the stock, and the president and secretary signatures (e.g., vice president of finance). Have the students compare the advantages and disadvantages of raising money through the sale of stock, use of personal capital, and securing loans.

4. Explain the relationship between labor and management within manufacturing enterprises. Using democratic procedures, have the students nominate and elect a union president and shop steward. Have representatives from labor and management develop, negotiate, vote on, and ratify a labor contract. The final contract should define things like safety policies, labor benefits, job descriptions, grievance procedures, and management responsibilities. Have students discuss the effects of good versus poor labor relations on things like morale, product quality, working conditions, productivity, and profit.

5. Discuss how products are often designed and manufactured to solve problems. Divide the class into research and development teams. Ask each team to identify and write a problem statement that requires a product for its solution. An example problem statement could be: Design a device that organizes articles commonly stored in a school locker (e.g., pens, pencils, paperbacks, calculators). Discuss how products are designed to address a specific problem or fulfill a need or want.

6. Introduce students to a variety of preliminary design techniques. Have each R & D team brainstorm possible solutions to the problems identified during the activity above. Have students draw thumbnail sketches for each design idea. When students have finished their thumbnail sketch, have them develop a rough sketch that identifies and/or combines their best design ideas. Ask students to explain why designers sketch their ideas before they draft the plans or make the product. Discuss the cost effectiveness of preliminary sketches early in the design process.

7. Show students the two and three dimensional techniques used to refine product designs. Using their rough sketch as a guide, have each R & D team draw a rendering of their product using colored pencils, markers or chalk and make a three dimensional mock-up using easy to work materials like styrofoam, clay, cardboard, or wood. Have each team evaluate their rendering and three dimensional mock-up based on design considerations like appearance, consumer demand, profit potential, ease of manufacturing, and safety. Ask students to evaluate the advantages and disadvantages of two versus three dimensional representations of a product design.

8. Introduce students to the concept of specifying a product design. Using traditional and/or computer-aided drafting/design tools, have each R & D team prepare a set of working drawings. Their working drawings should include things like multi-view drawings, assembly drawings, specifications, and a bill of materials. Have the students explain how working drawings can effect the final product's quality, safety, assembly, serviceability, and profit potential.

9. Introduce the students to the concept of market research. Based on their product's design, have each R & D team develop and conduct a market survey. Their survey questionnaire should include items about the respondent's age, gender, and occupation, the price for the product, how the product could be used, the appearance of the product, how the product competes with similar products on the market, and how the product can be improved. Have students explain how the information gathered through market research can influence design, marketing, and manufacturing decisions.

10. Discuss the importance of prototypes in the product development process. Using basic building materials like wood, plastic, metal, and fasteners, have each group of students build, test, and evaluate a full scale working prototype. Each prototype should be evaluated on things like safety, function, design, cost, durability, ease of servicing, and ease of manufacturing. Have students explain how testing and evaluating prototypes may effect safety, efficiency and profit.

11. Discuss the steps involved with preparing and presenting a product proposal. Using plans and specifications, mock-ups, renderings, prototypes, market research data, and presentation media, have each R & D team prepare and present a proposal for the product to be manufactured by the class. Each proposal and presentation should include information on marketing, financing, and manufacturing the product. Ask students to evaluate and select the best proposal based on design considerations like safety, function, appearance, cost, durability, and the ease of manufacturing and servicing. Have the students explain the importance of evaluating each proposal before selecting and manufacturing a new product.

12. Show students the techniques used to analyze a product and design a production system. Using the prototype as a guide, have students representing the production department develop a flow chart for each component and an operation chart for manufacturing the product. The charts should illustrate things like operations, inspections, transportations, delays, and storage functions. Ask students to explain how production charts can be used to design tooling, facilities, material handling systems, and quality control procedures.

13. Introduce students to the concept of plant layout. Using equipment templates and floor plans or computer-aided drafting/design systems, have students from the production department design a plant layout for their manufacturing enterprise. Design considerations for the plant layout should include things like the space needed for production; the production sequence; the location of machine, work stations and material handling devices; and the storage space needed for raw materials and finished goods. Use the final plant layout to set up a manufacturing facility. Have the students discuss how plant layout can effect a product's final selling price.

14. Introduce students to the devices used to move materials, assemblies, and finished products during the production process. Using materials and equipment like wood, metal, plastic, cardboard, rollers, fabric, motors, and robots, have a group of students design, build, test, and maintain a materials handling system. The materials handling system could feature devices like conveyers, robots, carts, chutes, rollers, and/or pneumatic tubes. Have the students discuss the applications, advantages, and disadvantages of various material handling devices.

15. Discuss the technology used to tool a manufacturing facility. Using basic building materials and fasteners, have students from the production department design, build, and test tooling for their production system. Depending on the product, the tooling could include things like jigs, fixtures, templates, molds, and dies. Ask students to evaluate their tooling devices in terms of design, accuracy, safety, and durability. Discuss how tooling can influence things like set-up time, material processing time, quality control, and plant efficiency.

16. Discuss the role automation is playing in modern manufacturing processes. Include technologies like CAD, CAM, CNC, DNC, CIM, and FMS in your discussion. Have small groups of students program a real or simulated computer numerical control (CNC) lathe, drilling, or milling machine to produce a simple object from a given piece of standard stock. Have students debate the pros and cons associated with automation from the management, labor, and consumer point of view.

17. Show students the techniques used to ensure product quality. Have students from the production department develop a system for maintaining quality before, during and after the manufacturing process. Ask students to design, develop, and test check lists and gauges for inspecting materials, components, assemblies and finished products. Ask students to discuss how techniques like statistical analysis and quality circles can be used to improve product quality and employee morale.

18. Introduce students to the concept of statistical process and quality control. Have students from the production department measure and record a critical dimension of a sample of components using a micrometer, vernier, and/or calibers. Using a teacher-prepared form, have students determine the mean, range, and/or standard deviation for the critical dimension. Compare the results with the specifics defined in the working drawing. Use the results to make decisions about tooling adjustments, cutting speeds, and feed rate. Ask students to explain the importance of being able to make informed quality control decisions in today's sophisticated manufacturing processes.

19. Explain how manufacturing companies establish and maintain safety standards. Using a teacher prepared check list, have a group of students conduct a safety inspection to identify potential safety hazards and develop strategies to ensure safety. The check list should include items about personal, hand tool, machines, equipment, and general safety. Use the information collected to establish a list of safety rules for the student enterprise and to promote safety with posters, slogans, and incentives. Have the students discuss and compare their inspection list with one from OSHA. Discuss the importance of safety in the work place from a company and worker perspective.

20. Explain the importance of timing when designing and implementing a manufacturing system. Using things like stop watches and a teacher prepared instrument, have students from the production department conduct time and motion studies to design and develop work stations. Use the data collected to train workers, refine tooling, adjust materials-handling systems, and improve quality control procedures. The goal should be to develop a just-in-time production system. Discuss the role just-in-time technology plays in helping American companies be competitive in a world economy.

21. Discuss the importance of testing the manufacturing process before full scale production begins. After setting up a manufacturing facility, have the students conduct a pilot run and manufacture two or three products. During the pilot run, have students identify and debug problems throughout the system. Students should look for things like overloading electrical circuits, products backing up, insufficient material handling devices, and unsafe working conditions. Ask the students to discuss how pilot runs can be used to improve things like safety, efficiency, and profit.

22. Introduce students to the concept of packaging finished goods. Discuss and show examples of various types of packaging techniques. Using tools and materials like plastic bags, poster board, dry transfer type, markers and/or electronic publishing, have students from the marketing department design and produce packaging for their products. The final packaging should protect and display the product, make the product easier to handle, attract potential consumers, and provide information about the product. Discuss the communication role of packaging in the sales and distribution process and how it can effect product appearance, cost, and sales.

23. Discuss the techniques used to promote the sale of manufactured products. Using tools and materials like video taping equipment, audio recording equipment, electronic publishing equipment, poster board, stencils, and markers, have students from the marketing department design, produce, and display advertisements for their student enterprise. Students should include techniques like announcements over the PA system, television commercials, displays, fliers, brochures, and/or posters to advertise their product. The final advertisement should attract the consumer's attention, inform the consumer about the product and the company, and persuade the consumer to purchase the product. Ask the students to discuss the advantages and disadvantages of using television and radio commercials; newspaper and magazine ads; and billboard and bus displays to advertise products. Discuss the ethical issue surrounding truth in advertising.

24. Describe the sales strategies and the distribution chains used to move products from the manufacturer to the consumer. Have students from the marketing department develop and implement a sales and distribution system for their product. Address issues like who is going to sell the product; when and where will sales be conducted; how to handle and document the exchange of money; and how and when will the product be delivered to consumers. Have students discuss the ethical, interpersonal, and legal issues associated with selling products.

25. Introduce students to concepts of closing an enterprise. Using the financial records from each department, have students from the finance department determine the cost associated with producing the product (e.g., labor, materials, overhead). Using cost and income figures, calculate company's financial condition. If the company has made a profit, figure the size of each stockholder's dividend. Along with financial information, have each department develop and present an annual report to a real or fictitious board of directors (e.g., school counselors, administrators, board members, and teachers). Send a copy of the annual report to each stockholder with their dividend. After the company has been dissolved, ask students to explain the relationship between risks and rewards in the free enterprises. Discuss ethical issues surrounding free enterprise.

26. Discuss the milestones in the history and evolution of manufacturing systems. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.

27. Discuss the career opportunities in manufacturing systems. Include occupations at the non-skilled, semi-skilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to manufacturing systems. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.

MANUFACTURING TECHNOLOGY

OVERVIEW

INTRODUCTION

Do you know what automobiles, refrigerators, televisions, telephones, clothing, heaters, vacuum cleaners, compact discs, computers, lawn mowers, furniture, and many food products have in common? They are all manufactured products. Can you imagine a world absent of manufactured items? As a society, we have become very dependent on these and other items.

What is manufacturing consists of people and/or machines converting various materials into products. These products are produced within an organization called a manufacturing enterprise. Manufacturing enterprises are typically owned by an individual or a group of individuals who invest time, money, and effort in order to make a profit. Most large manufacturing enterprises consist of three main departments: 1) research and development, 2) production, and 3) marketing.

Research and Development

Research and development (R & D) is a process used by manufacturing enterprises to create new products and/or modify existing products. R & D can also be used to improve the techniques, methods, or processes used to make the product. R & D is typically carried out by a group of people working as a team. R & D teams identify problems or needs; research and develop possible solutions; test and evaluate solutions; determine consequences; and present and implement solutions.

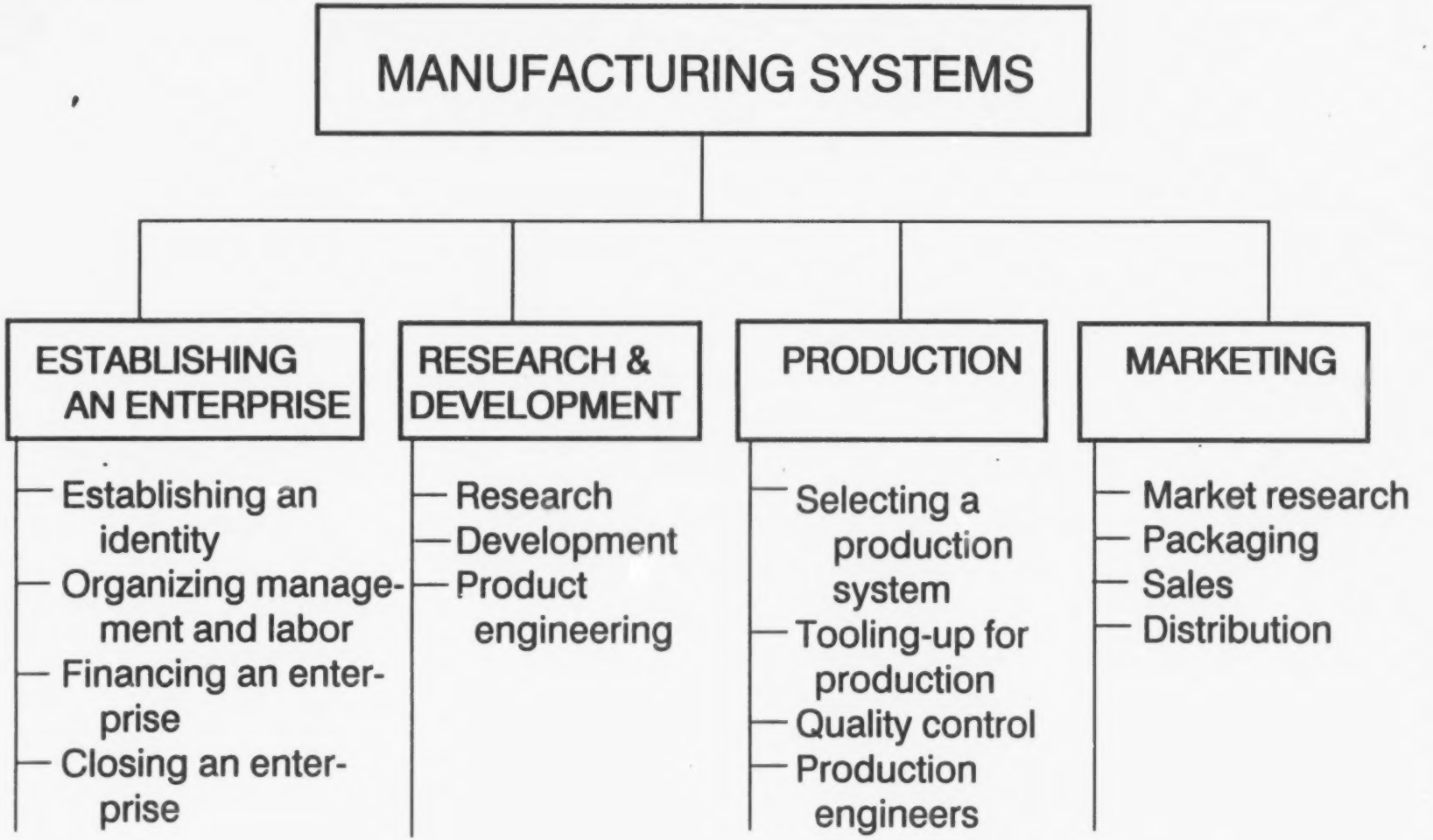
Production

Once a product idea makes it through all phases of research and development, it is up to the production department to build it. In most manufacturing enterprises, production is involved with activities like planning plant layout, developing materials handling systems, designing tooling devices, creating a safe working environment, ensuring quality products; and incorporating automated systems.

Marketing

After a product is produced, it must then be marketed. Marketing involves four major activities: 1) market research, 2) packaging, 3) advertising, and 4) distribution. Marketing provides the manufacturing enterprise a link to the consumer. Through marketing, the general public is made aware of the product, how much it will cost, what it will do, and how to obtain it.

The series of Technology Education Activities which follow, will allow students hands-on experiences with each phase of manufacturing. Students will experience activities relating to researching and developing a product, organizing a manufacturing enterprise, establishing a production system, and creating marketing strategies.

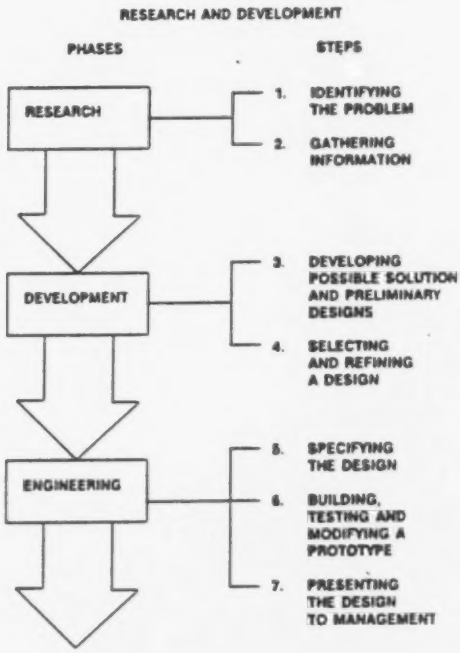

MANUFACTURING SYSTEMS
ESTABLISHING AN ENTERPRISE
Establishing an identity
Organizing management and labor
Financing an enterprise
Closing an enterprise
RESEARCH & DEVELOPMENT
Research
Development
Product engineering
PRODUCTION
Selecting a production system
Tooling-up for production
Quality control
Production engineers
MARKETING
Market research
Packaging
Sales
Distribution

RESEARCH AND DEVELOPMENT

Introduction

People have a variety of wants and needs. Many of our wants and needs are fulfilled by the products we purchase and use every day. We purchase food to meet our need for nourishment, houses to meet our need for shelter, and automobiles to meet our need for transportation. The goal of people who work in research and development is to create products that satisfy our wants and/or needs. In addition, these products need to be able to make a profit for the company.

New products do not just magically appear, but evolve through three phases: 1) research, 2) development, and 3) engineering. Typically, the evolution of a new product begins with a problem. The people in research and development follow a basic series of steps when creating a new product. These steps are listed below.



The following series of Technology Education Activities will allow students to experience each phase of Research and Development. Students will be involved with activities related to the creation of a new product. Students will identify a problem or need, gather information, develop possible solutions and preliminary designs, select and refine a design, build and test a prototype, and present the design to management for approval.

Identify the Problem

The first step in the process is to identify and analyze the problem. Problems are basically opportunities to improve our quality of life. To identify a problem, we can observe life around us and look for ways to improve it. For example, you are talking to a sales person in a store about purchasing a stereo system. The sales person under stands your needs and has been very helpful. Before you purchase a system, you want to shop around a little more. However, you want to be able to ask for this sales person if they prove to have the best price, so you ask for a business card. The sales person looks through their wallet, pockets and desk drawers before finding a business card behind the sales counter. Once you leave the store, you think to yourself, "I should not have had to ask for a business card, I should be able to just pick one up at the sales counter."

Before a problem can be solved, it must be understood. The first step in understanding a problem is to define it accurately in the form of a problem statement. An appropriate problem statement for our business card example would be:

> Design a device that displays and dispenses business cards on a sales counter or desktop.

The next step in understanding the problem is to analyze it and make a list of design specifications for solving the problem. Design specifications describe your goals for the product. They describe the characteristics the product must have to solve the problem. The design specifications for the business card problem might include the following:

* The device should encourage people to take a business card.
* The device should display the cards so they can be easily read while standing in front of a sales counter or sitting in front of a desk.
* The device should allow customers to take one card without disrupting the rest of the cards in the holder.
* The device should be pleasant to look at and should fit in with other desktop organizing devices.

The last step in understanding a problem is to identify the limitations that must be taken into account when solving the problem. It would be a waste of time to design a plas tic product if the manufacturer is only equipped to process wood and metal. You would not want to design a product that will cost a million dollars to make if you can only afford to invest ten thousand dollars. The six basic types of limitations are:

* human resources
* material resources
* facility limitations
* time limitations
* information resources
* financial resources

The limitations for a student enterprise addressing the business card problem might include the following:

* We can manufacture the device out of wood or plastic.

* We must be able to manufacture the device using simple woodworking tools and machines.
* We can involve up to fifteen people in the manufacturing process.
* We only have two weeks to manufacture the device.
* The device should not have more than four parts.
* We can raise approximately $50 to finance the project.
* We want to make as big a profit as possible.

The people in research and development develop new products to solve the problems we face today. The first step in solving a problem is to define it accurately and analyze it. Before we can solve a problem, we must be able to define it clearly, list the specifications for its solution, and list our limitations.

Problem Statement

You have been hired as a product designer in the Research and Development Department for a company. The company wants to expand their products. It is your team's responsibility to identify a potential product.

Activity Procedures

1. The first step in the research and development process is to observe a situation and identify a problem or an opportunity to make improvements. Your design team needs to study the situation and identify a specific problem that can be solved with a new product.

2. Once you have identified a problem, your team needs to define it accurately. In the space provided, write a problem statement that describes the problem you would like to solve with a new product.

_____

_____

_____

3. Once you have defined the problem accurately, your design team needs to list the specifications for the solution. You are basically answering the question, what must the product do? In the space provided, list the specification for the solution to your problem.

   The device must:

   a. _____

   b. _____

   c. _____

The device must:

a. _____

b. _____

c. _____

d. _____

e. _____

f. _____

g. _____

h. _____

4. Next, your design team needs to list the limitations that must be taken into account when trying to solve the problem. Discuss each of the following questions. Circle the items that best describe your problem-solving limitations. You may need to circle more than one item. Feel free to write in your own answers if the ones provided are not appropriate.

1. What kinds of materials are readily available and reasonable in cost?

   a. wood
   b. metal
   c. plastic
   d. paper
   e. ceramics
   f. leather
   g. other _____

2. The budget for manufacturing the product will be about ____ dollars.

   a. 20
   b. 30
   c. 40
   d. 50
   e. other _____

3. How many units can you produce and sell?

   a. 10-25
   b. 25-50
   c. 50-100
   d. 100-150
   e. other _____

4. Who will you be selling your product to?

   a. students
   b. teachers
   c. parents
   d. the general public
   e. other _____

5. How much time is available to manufacture the product?

   a. 1 week
   b. 2 weeks
   c. 3 weeks
   d. 4 weeks
   e. other _____

6. How many students need to be involved in the manufacturing process?

   a. 10-15
   b. 15-20
   c. 20-25
   d. 25-30
   e. other _____

7. What kinds of tools and machines can be used during the manufacturing process?

   a. wood, metal, and leather working hand tools (e.g., screw drivers, chisel, rubber mallet)
   b. plastic and ceramic hand tools (e.g., plastic cutter, paper stripper, clamps)
   c. portable equipment (e.g., drills, saber saws, sanders, router, strip heater, hot plates)
   d. stationary equipment (e.g., table saw, drill press, lathe, belt sander, jointer, planer, band saw, miter box, oven, injection molder)
   e. automated systems (e.g., CAD/CAM systems, CNC systems, computer hardware, computer software, printers)

Activity Analysis

1. Write a problem statement for the following situation. Students are constantly having problems finding things in their lockers. Papers are torn, pencils are lost.

   Problem Statement

   _____

   _____

   _____

2. What is a potential product that could solve the problem?

Gathering Information

Once a problem has been identified and accurately defined, it needs to be researched. Research is a systematic process for discovering and gathering information to solve the problem.

There are two basic types of research, pure research and applied research. Pure research is basically gathering information to learn more about a given subject. Learning how far you can bend various materials before they will break is an example of pure research.

Applied research is basically gathering information that will help solve a specific problem. Testing the strength of various materials to build a light weight bicycle frame is an example of applied research.

The next step in the process is to make a list of research questions. Research questions identify what you need to know to solve the problem. A set of research questions for the business card problem might include the following:

1. How many cards should be displayed at a time?

2. How big are most business cards?

3. What do the business card holders on the market look like?

4. How much do the business card holders on the market cost?

5. Should business cards be displayed horizontally or vertically?

6. What kinds of materials are used to make most desktop organizing devices?

Research questions can be answered by asking experts, reviewing reference materials, conducting surveys, or conducting experiments. Which method is best depends on the question. To learn the dimensions for standard business cards, you could ask a professional printer. Experts in industry can be contacted in person, by phone, or by writing a letter. When you ask experts for help, it is important to introduce yourself, to explain what you are doing, and to state your questions clearly.

To learn how many business cards should be displayed, you could survey local merchants. During the survey you could ask them how many business cards they give out each week. A survey is basically a list of questions and a checklist of possible answers. When you conduct a survey, it is very important to introduce yourself, to explain what you are doing, and to ask your questions clearly.

To learn about the business card holders currently on the market, you could review a variety of office supply catalogs. During the review you could determine what business card holders look like and how much they cost. In addition, you could identify the materials used to make desktop organizers (i.e., pen holders, book ends, memo pad holders, etc.). A good place to begin for a review of literature is your school library.

To learn whether business cards should be displayed vertically or horizontally, you could conduct an experiment. In the experiment, you could display two business card holders, one vertical and one horizontal, and ask people to take a business card. The business card holder people pick from the most would be the best design. When you conduct an experiment, it is important to consider the factors that can effect the results. For example, people might pick business cards from one holder because it is on the right versus the left. Or, they may pick from the one that has the fewest cards in it. It is important to think ahead and control as many factors as possible when conducting an experiment.

The last step in the research process is to report the information you have collected. During this step, you need to answer your original research questions.

The people in research and development conduct research to discover and gather information. To gather information, a researcher can consult experts, review reference materials, conduct surveys, and conduct experiments. When researching a problem, you need to state the problem, make a list of research questions, design the research activity, collect the information, and report your results.

Problem Statement

Once your design team has identified a problem, it is time to conduct the research. As a team, develop a method for researching your product.

Activity Procedures

1. The first step in researching your problem is to state the problem. Write your problem statement in the space below.

Research Project Problem Statement

_____

_____

2. The next step is to identify the information needed to solve the problem. You can do this by asking yourself: What do I need to know? Analyze your problem statement and write a list of research questions in the space below.

Research Questions

1. _____

_____

2. _____

_____

3. _____

_____

4. _____

_____

5. _____

_____

6. _____

_____

3. The next step is to identify how you are going to answer each research question. You can answer questions by asking experts, reviewing reference materials, conducting a survey, and/or conducting an experiment. Which method you use depends on the question. One method may work for one question but not another. Analyze each question carefully and write how you are going to obtain the information you need.

Methodology

Question No. 1: _____

_____

_____

Question No. 2: _____

_____

_____

Question No. 3: _____

_____

_____

Question No. 4: _____

_____

_____

Question No. 5: _____

_____

_____

Question No. 6: _____

_____

_____

4. The next step in the process is to collect the information you need to solve your problem. When you have finished gathering information, use the space provided to answer each research question.

Final Report

Question No. 1: _____

_____

_____

Question No. 2: _____

_____

_____

Question No. 3: _____

_____

_____

Question No. 4: _____

_____

_____

Question No. 5: _____

_____

_____

Question No. 6: _____

_____

_____

Developing Preliminary Designs

During the research process, the goal is to gather the information needed to solve a problem. During the development process, the goal is to use the information gathered to design a solution to the problem. The first step in the development process is to create a variety of possible solutions to the problem. These solutions are called preliminary designs. Designers use two creative thinking techniques to help them create preliminary designs, visualization, and brainstorming.

Visualization is the ability to think using mental pictures. Designers use their imaginations to create new products. The first step in the visualization process is to create a clear mental picture of an idea. The next step is to use the mental picture to draw a visible picture on paper.

Designers use thumbnail sketches to record their ideas. Thumbnail sketches are drawn quickly and very rough (see Figure 3-1). Detail is not important during this stage of the development process. If an idea has promise, a detailed drawing can be made later.

Thumbnail sketches play several important roles during the visualization process. First, they help the designer visualize their ideas and create more ideas. Second, they allow the designer to store their ideas so they can visualize a new idea. Lastly, they help the designer communicate their ideas to others.

The goal of brainstorming is to think freely and generate as many ideas as possible. Quantity is more important than quality. During the brainstorming process, it is important to encourage creative thinking. Therefore, no one is allowed to judge ideas as they are being born. Every idea is given a chance and every idea is recorded, even if they seem silly at the time. Sometime, silly ideas prove to be the best ideas or they lead to better ideas.

Brainstorming is typically a team effort. All the members of the team need to feel they can contribute ideas without fear of criticism. If one member's ideas are called silly or stupid, they may stop contributing ideas and the best idea may never be discovered.

Using information to create a new product is called development. The first step in the development process is to create a variety of preliminary designs. Designers use visualization and brainstorming techniques to create preliminary designs. Designers record their ideas by drawing simple sketches called thumbnails.

Materials and Supplies

- Paper
- 1/4" or 1/8" grid paper
- Pencils

Problem Statement

The next stage of the design process is to begin visualizing the product. As a design team, create several sketches of products which will solve the problem.

Activity Procedures

1. In your design teams, review your problem statement, design specification, and research information. Use the visualization and/or brainstorming techniques to create as many preliminary designs as possible. Draw a thumbnail sketch for each design idea on graph paper. Keep your sketches small and simple. Do not worry about neatness and accuracy. Do not evaluate your ideas. Concentrate on creating and recording.

Selecting and Refining a Design

The problem-solving process has several stages. You have already identified a problem, gathered information about the problem, and developed a variety of preliminary designs. The next step is to evaluate each preliminary design.

The purpose of the evaluation process is to identify the best design. To identify the best design, designers use a list of design considerations to evaluate each preliminary design. A typical list of design considerations might include things like:

* function
* appearance
* safety
* ease of servicing
* market appeal
* cost
* ease of manufacturing
* durability

During the evaluation process, each design consideration can be put into the form of a question. Together, all the questions make a test. The following test questions could be used to evaluate the preliminary designs for the business card holder problem.

1. Will the design do what it is suppose to do?
2. Is the design pleasant to look at?
3. How much will it cost to manufacture the design?
4. Is the design safe to manufacture and use?
5. Can the design be serviced easily?
6. Will people purchase the design?
7. How hard will it be to manufacture the design?
8. How long will the design last.

At the end of the evaluation process, one preliminary design might prove to be the best. Or, a combination of ideas from several preliminary designs might be combined to make the best design.

Once the best design has been identified, it needs to be refined (improved). Designers refine designs by making detailed drawings and/or models. They help the designer discover what the final product will look like and how it can be made.

To refine a design through drawings, a designer must first draw a rough sketch. A rough sketch is larger and includes more detail than a thumbnail sketch. After drawing a rough sketch, the designer is ready to develop a rendering. A rendering is a very lifelike picture of the design. Sometimes, they are so lifelike they look like photographs. They include a lot of detail and they are often drawn in color. Since they are so lifelike, rendering can be used to ask consumers what they think of the new product before the first one is even made.

A drawing can provide only a two dimensional representation of a design. The primary advantage of a model is that it can represent a design in three dimensions. You can pick up a

model and look at its front, top, back, bottom, and sides. The models made during the development process are called mock-ups. There are three basic types of mock- ups. The simplest is called a paste-up mock-up. They are typically made out of easy to work materials like paper, cardboard, clay, wood, or styrofoam. Paste-up mock-ups allow the designer to see what the product will basically look like without spending a lot of time and money.

Appearance mock-ups are models that look like the real thing. They are typically full size. However, they usually do not have any working parts. They can be made out of any material that can create the lifelike appearance. An appearance mock-up of a stereo would look real from a distance. However, up close, you would most likely discover the controls do not work. If you pick it up, you might discover it is nothing more than a hollow plaster shell. The materials commonly used to make appearance mock-ups include wood, plastic, and clay.

The most realistic and detailed models are called hard mock-ups. For all practical purposes, hard mock-ups look and work like the real thing. However, they do not include the internal parts that would allow the product to work. They are typically made out of the materials that will be used to make the final product. A hard mock-up of a stereo might include working knobs and switches. It may even have a tape door that opens and closes. However, it would not include the electronics that would enable you to tune in a radio station or play a cassette tape.

The first step in the development process is to develop a variety of preliminary designs. A list of design conside rations are used to evaluate each design and identify the best design. Once the best designs have been identified, the design is refined through rough sketches, renderings, and/or mock-ups. During the refinement process, the design evolves from a rough idea sketch on paper to a very lifelike drawing and/or model.

Materials and Supplies

- Styrofoam
- Paper
- Traditional drafting tools
- Optional: Computer and popular CAD program

Mock-up materials might include:

- Foam core
- Balsa wood or pine
- Clay
- Poster Board
- Glue
- Nails

Problem Statement

As a design team, it is your job to select and refine a product idea. Once the product has been refined through drawing, it should be made into a three dimensional mock-up.

Activity Procedures

1. In your design teams, use the questions listed below to discuss and evaluate each of your preliminary designs. Try to find good ideas in each design. During the evaluation process, write notes near each sketch that identify good ideas and possible problems.

   - Will the design do what it is suppose to do?
   - Is the design pleasant to look at?
   - How much will it cost to manufacture the design?
   - Is the design safe to manufacture and use?
   - Can the design be serviced easily?
   - Will people purchase the design?
   - How hard will it be to manufacture the design?
   - How long will the design last?

2. When you have finished evaluating each design, review your notes and select the best design. You may find one idea is clearly the best. However, you may need to combine good ideas from several designs to create the best design. Make sure your best design meets all the design considerations.

3. After you have identified the best design, it needs to be refined. The first step in the refinement process is to develop a final sketch. Your final sketch should be larger and include more detail than your thumbnail sketches. Try to improve your design as you draw. Do not be afraid to make changes.

4. Using your final sketch as a guide, use the materials provided by your teacher to make a mock-up of your design. Make sure you protect the table top when you are cutting and gluing materials. Try to make your mock-up the same size as the final product.

Specifying the Design

During the research process, the goal was to gather information needed to solve a specific problem. During the development process, the goal was to create a product that will solve the problem. The next phase of the research and development process is called product engineering. During this phase, the goal will be to make the product that will solve the problem.

The first step in the product engineering process is to specify the design. The purpose of specifying the design is to determine how to make the product. When it is time to make the product, production people will need to know:

* how many parts to make.
* the size and shape of each part.
* what kind of material to use when making each part.
* how to put the parts together.

To specify a design, engineers draw a set of plans for the design using drafting tools or a CAD (computer-aided- design) system. Drawing a set of plans plays two important roles during the design specification process. First, they allow engineers to test their ideas on paper before they try to make the product. Second, they help the engineers tell the production people how to make the product.

If the design is entered into a CAD system, a computer simulation can be used to test the design and identify problems. When problems are discovered, the engineer can use the CAD system to improve the design. When the design is complete, the computer can be used to draw plans and/or program production equipment to manufacture the product.

The plans used to manufacture a product are called working drawings. Working drawings use a variety of communication tools to describe the product. Detailed drawings are used to show how to make each part. They typically show the part from a variety of views. Most detail drawings include a front, top, and side view of the part. Sometimes, detail drawings use a cut-away view to show details inside the part. Dimensions are used to describe the size and shape of the part.

Assembly drawings are used to show how the parts fit together. Assembly drawings help production people understand how to put the product together.

Schematic drawings are used to describe electrical or fluid power systems. Schematics use a variety of symbols to represent each component in a system. Lines are used to show how the components are connected together.

A bill of materials is used to describe materials needed to make each part. A bill of materials is basically a list of the parts needed to make the product. A bill of materials will list the name of each part, describe its basic dimensions, identify the material used, and list the quantity needed.

Notes and specifications are used to provide information that cannot be drawn. For example, you cannot draw the finish used to protect the product. You can describe what finish to use, how many coats to apply, and how long to let it dry in the notes or specifications.

The goal of product engineering is to build the product. The first step in building the product is to specify the design. To specify the design, product engineers use drafting tools or a CAD system to develop a set of working drawings. Working drawings describe the size, shape and features of the product. Production people will use the working drawing to program production machines to make each part and assemble the final product.

Materials and Supplies

- SH #1-7
- Traditional drafting tools

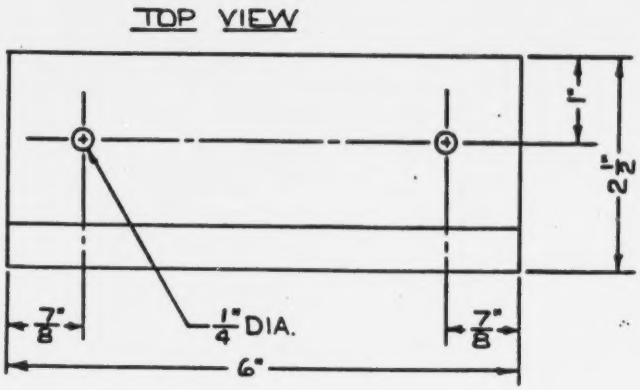
OPTIONAL: Computer and popular computer-aided drafting program (e.g., AutoSketch, CAD Draw)

Activity Procedures

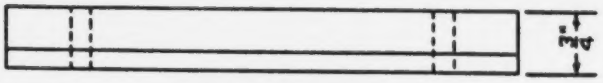
1. Your design team needs to specify the design by developing a working drawing, a bill of materials (SH #1), and a specification sheet (SH #2). You can divide these tasks among the members of your design team. For example, one or two team members can draw the plans, another team member can develop a bill of materials, and another team member can complete the specification sheet.

2. Use your final sketch and your mock-up as a guide when specifying your design. In addition, you may want to refer to the examples provided for a business card holder (SH #1-3).

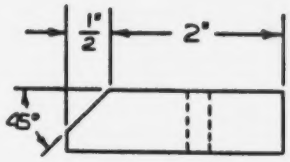
SH #1



SCALE: 3/4" = 1"



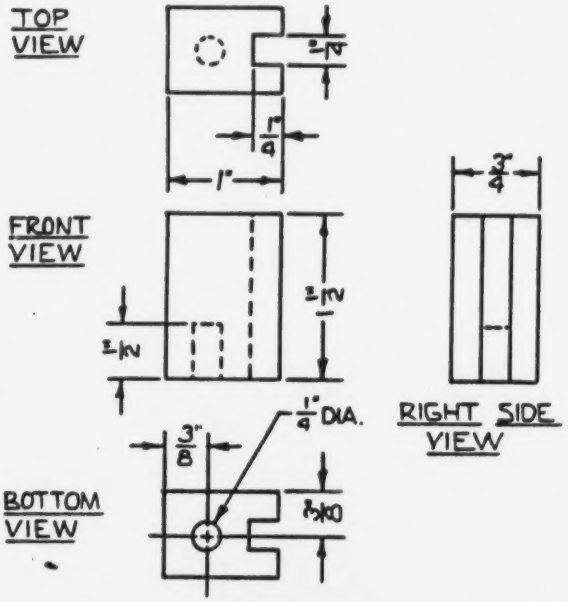
FRONT VIEW



RIGHT SIDE VIEW

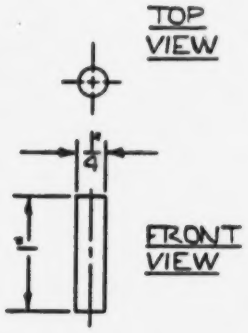
NAME: JOHN SMITH	BUSINESS CARD HOLDER	PART: BASE	DATE:

SH #2



HOLDER

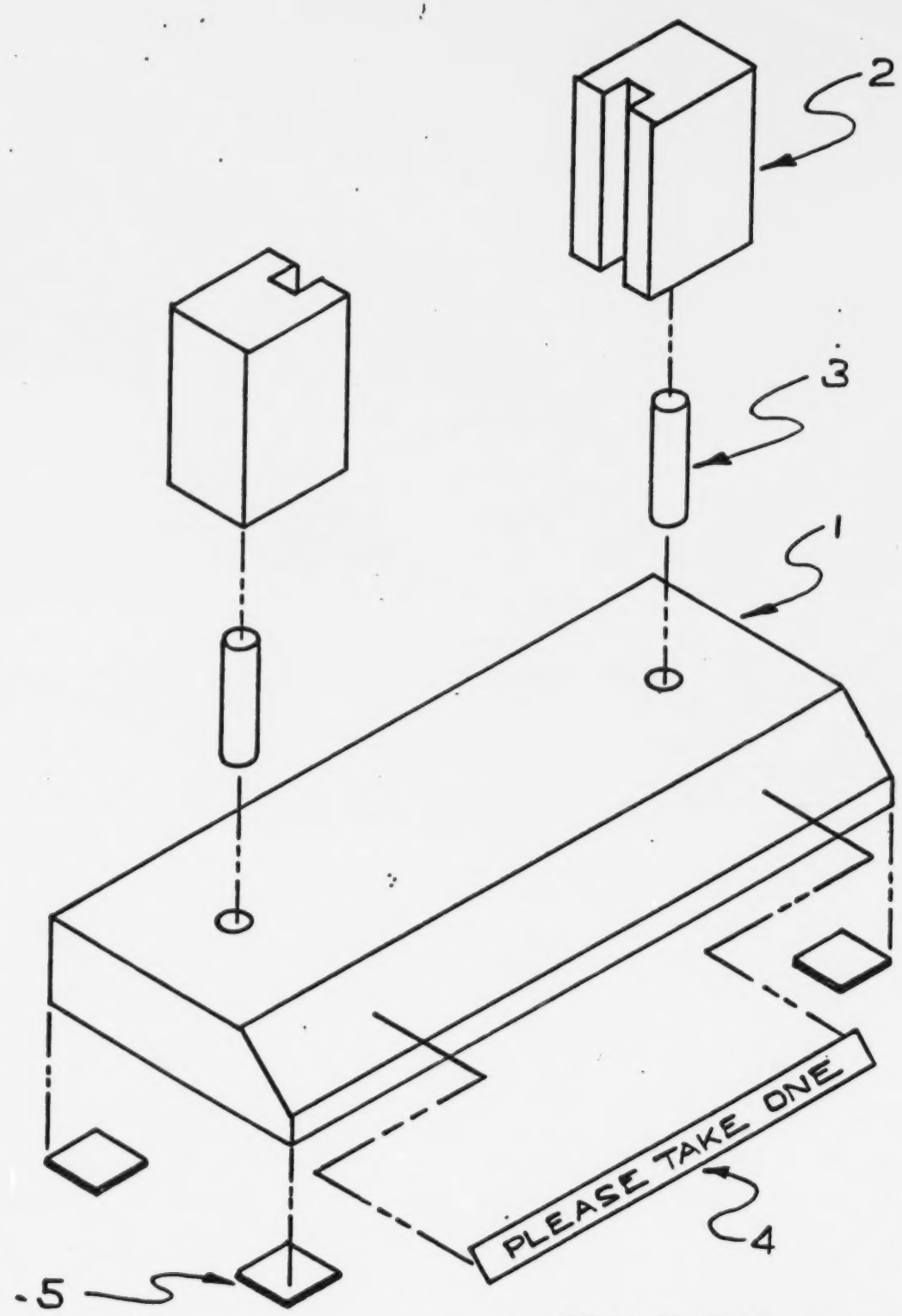
RIGHT SIDE VIEW



DOWEL

SCALE: 1" = 1"

NAME: JOHN SMITH	BUSINESS CARD HOLDER	PART: HOLDER + DOWEL	DATE:



SCALE: 3/4" = 1"

NAME: JOHN SMITH	BUSINESS CARD HOLDER	ASSEMBLY

BILL OF MATERIALS

PART NUMBER	PART NAME	MATERIAL	DIMENSIONS L×W×D	QUANTITY
1	BASE	MAHOGANY	6" × 2 1/2" × 3/4"	1
2	HOLDER	MAHOGANY	1 1/2" × 1" × 3/4"	2
3	DOWEL PIN	BIRCH	1" × 1/4" DIA.	2
4	LABEL	PLASTIC	4 1/2" × 3/8"	1
5	PADS	FELT	1/2" × 1/2"	4

SPECIFICATION SHEET

ADHESIVE: USE WHITE GLUE TO FASTEN HOLDERS, DOWEL PINS, AND BASES TOGETHER. CLAMP FOR ONE HOUR. ALLOW TWENTY FOUR HOURS TO DRY.

FINISH: RUB IN TWO COATS OF TUNG OIL WITH A CLOTH. ALLOW TWENTY FOUR HOURS BETWEEN COATS.

BILL OF MATERIALS

PART NUMBER	PART NAME	MATERIAL	DIMENSIONS L x W x D	QUANTITY

23-M

SH #6

SPECIFICATION SHEET

24-M

SH #7

Building and Testing a Prototype

The first step in the product engineering process is called specifying the design. The goal is to determine how to build the product. During the design specification stage, a set of working drawings are developed. The next step is to actually build the product.

The first product built according to the plans is called a prototype. Since the production system has not been built yet, the prototype must be made by hand in a special facility. Because they are custom-made, prototypes are very expensive to build. A prototype for a new automobile can cost millions of dollars to build.

Prototypes play several important roles during the product engineering process. Product engineers use a prototype to test the plans, evaluate the design, and learn how to manufacture the product.

Product engineers use the working drawings drawn during the design specification process to build the prototype. If there are any mistakes on the drawings, the engineers building the prototype will find and correct them. Sometimes, design changes are made because the product engineers discover new and better ways to build the product while building the prototype. Just like drawing sketches, making mock-ups, and drafting plans, building the prototype represents another opportunity to improve the design.

Once the prototype has been built, the design can be tested. Sometimes, new products do not work as well in real life is they do on paper. Prototypes help product engineers discover and solve problems. If there are flaws in the product's design, product engineers want to find them during product testing. Problems not found during product testing are mass produced with the product. It is very expensive to solve problems once production begins.

Product engineers use the prototype to make sure the product works properly, is safe to use, is durable, and can be serviced easily. During product testing, prototype auto mobiles are driven on a test track and subjected to tests. These tests are used to evaluate things like handling, braking, acceleration, endurance, and comfort. Prototypes are often destroyed during safety tests. Sometimes, automobile prototypes are shown at car shows to get public reaction to new designs.

Product engineers often help production engineers develop the production system used to manufacture a new product. Building the prototype helps the product engineer understand the relationship between various components. This experience can be very useful when planning a production line. Knowing how to build a product by hand is often the first step in learning how to build a product on an automated assembly line.

After the plans have been drawn, product engineers are ready to build the first product. The first product made according to the plans is called a prototype. Prototypes are custom-made and cost more to build than the final product. Prototypes can be used to test the plans, test the design, and learn how to manufacture the product. To determine whether or not the public will buy your product, the prototype can be used to conduct market research. Market research tries to answer questions like: Who will buy the product? How much will people pay? What can be improved? This type of information can be collected through a market survey.

Materials and Supplies

- Set of working drawings as created in previous activity
- Market Survey Sheet

Activity Procedures

1. Your design team needs to build and test a prototype. Using your plans as a guide, divide your product into specific parts. Each member of your team will build one or two parts. Make sure you build each part according to your plans. NOTE: Be sure to check with your instructor before using any tools or equipment.

2. After all the parts have been made, assemble them into a prototype. If the parts do not fit together as planned, identify the problem and make the necessary adjustments. Make sure you record all design modifications on your plans.

3. When your prototype is complete, it needs to be tested. Using the form provided, below evaluate your prototype. Since each team's prototype is different, you will need to develop your own test for each question. After each test, answer the question and write a few comments in the space provided. Make sure your prototype meets your original design specifications. Refer to the example prototype evaluation form for ideas.

Prototype Evaluation Form

1. Is your product safe to use? (Yes or NO)

_____

2. Is your product functional? (Yes or NO)

_____

3. Can your product be serviced easily? (Yes or NO)

_____

4. Is your product pleasant to look at? (Yes or NO)

_____

5. Do people want to buy your product? (Yes or NO)

_____

6. Is your product durable? (Yes or NO)

_____

7. How much will it cost to make your product? $_____

8. Will your product be difficult to manufacture? (Yes or NO)

_____

Market Survey

Activity Procedures

1. Show your prototype to a prospective customer. Allow them to hold the product and examine it carefully.

2. After introducing yourself and asking permission to conduct the survey, ask them the questions listed below.

3. Record their opinions by circling the most appropriate response under each item.
   Product _____

Consumer Information

1. Type of person surveyed

   A. student
   B. parent
   C. teacher
   D. Other _____

2. Sex of the person surveyed

   A. male
   B. female

Market Information

1. Would you purchase this product?

   A. yes
   B. no
   C. maybe

2. If yes, how many would you purchase?

   A. one
   B. two
   C. three
   D. other _____

3. What would you expect to pay for a product like this?

   A. 50 cents - $1.00
   B. $1.00 - $2.00
   C. $2.00 - $5.00
   D. More than $5.00

4. How could this product be improved?

   _____
   _____

Presenting a Design for Approval

Before a product can be manufactured, the people in research and development must get management's approval. The last step in the research and development process is to convince management the product works, people will buy it, and it will make the company a profit.

To convince management to manufacture a new product, a team of people from research and development make a formal presentation. During this presentation, they tell management about the new product. A typical presentation will include things like:

* why there is a need for the product.
* what makes the product useful.
* how their product compares with other products on the market.
* how long the product will last.
* who will buy the product.
* how much the product will cost to manufacture.
* the projected selling price for the product.
* how much profit can be made on each product.
* what kinds of tools, materials, and machines are needed to manufacture the product.
* what kind of human resources are needed to manufacture the product.

The presentation can be as important as the product's design when trying to convince management to manufacture the product. As far as management is concerned, the product can only be as good as the people who designed it. Management needs to know that the people who designed the product know what they are talking about and that they believe in their product and its design.

During the presentation, research and development people must become sales persons. Their presentation needs to be planned carefully. They need to speak clearly and with confidence. They need to use a lot of visuals (i.e., prototypes, drawings, plans, charts, graphs, pictures). They need to make eye contact with their audience. Lastly, they need to be able to anticipate and answer management's questions.

If management likes what they hear, they will give the "go-ahead" to manufacture the product. If management does not like what they hear, it is back to the drawing board to make modifications or to design a new product.

Before a product can be manufactured, management has to approve the design. To convince management to produce their product, a team from research and development needs to make a formal presentation explaining the merits of their product. The presentation will include product, market, financial, and manufacturing information.

Problem Statement

Your design team has been working a long time to develop the best product possible. The other design teams in your class have also worked hard to develop good products. However, your class can only manufacture one product during your manufacturing unit. You need to

convince the other members of your class that your product is the best product for your manufacturing experience.

Materials and Supplies

- Product Peer Evaluation Form (SH #1)

Activity Procedures

1. Each design team will be given an opportunity to present the merits of their product. Your team needs to prepare a presentation that includes product, market, financial, and manufacturing information. You may want to assign each team member a topic. For example, one member of the team could present product information, another could present financial information, and so on.

   The team member in charge of the product information could:

   * state the problem.
   * list the design specifications for the product.
   * describe how your team went about solving the problem.
   * discuss the solutions you considered (your prelimi nary designs).
   * describe your final product design.

   The team member in charge of market information could:

   * describe the target market (the group of people for which the product is designed).
   * summarize your market research information.
   * discuss how your product compares with other products on the market.

   The team member in charge of the financial information could:

   * report how much it costs to make the product.
   * discuss the product's projected selling price.
   * estimate the profit margin for each unit sold.

   The team member in charge of the manufacturing information could describe:

   * the materials needed to make the product.
   * the tools and machines needed to make the product.
   * the processes needed to make the product.
   * the people needed to make the product.
   * how the product is assembled.

2. Your presentation could center around a display. The display could feature your problem statement, design specifications, preliminary designs, final product sketch, mock- up, market survey, and the prototype. During the presentation, team members could refer to the display. In addition, items from the display could be removed and passed around the class.

3. Lastly, one member from the group could make a short statement summarizing why your product should be mass produced during your manufacturing unit. At the end of your presentation, ask your audience if they have any questions.

4. When you have finished planning your presentation, conduct a rehearsal. During your rehearsal, practice your lines, speaking clearly, making eye contact with your audience, and using visuals. Take turns asking and answering questions. After all, "practice makes perfect."

PRODUCT PRESENTATION PEER EVALUATION FORM

1. After each product presentation, rate all of the presentation elements listed on the left on a scale of one to five.

Team Members: _____

_____

_____

_____

Product Presented: _____

1	2	3	4	5
very poor	poor	average	good	excellent

Presentation Content:

Product information	1 2 3 4 5
Market information	1 2 3 4 5
Financial information	1 2 3 4 5
Manufacturing information	1 2 3 4 5

Presentation Skills:

Use of visuals	1 2 3 4 5
Communication skills	1 2 3 4 5
Eye contact	1 2 3 4 5

Activity Analysis

Directions: Read each question carefully. In the blank provided, write the letter of the answer option which best completes or answers the question.

_____ 1. The first step in a design process is to _____.

A. select the best solution.
B. gather information
C. makes a prototype
D. identify the problem

_____ 2. Which of the following is not a basic part of the product profile.

A. problem statement
B. thumbnail sketches
C. design specifications
D. company limitations

_____ 3. Which of the following is not part of the brain storming process?

A. generating ideas freely
B. evaluating ideas
C. recording all ideas
D. teamwork

_____ 4. Research is _____.

A. a systematic way to solve problems
B. a systematic process for discovering and gathering information
C. using information to design a solution to a problem
D. preparing a design for manufacturing

_____ 5. Which of the following is a good source for information?

A. libraries
B. government agencies
C. industry
D. all of the above

_____ 6. Conducting research to learn more about a mate rial (wood, metal or plastic) would be an example of _____.

A. applied research
B. pure research
C. product development
D. product engineering

_____ 7. During brainstorming activities, ideas are recor ded in the form of _____.

A. detailed drawings
B. mock-ups
C. renderings
D. thumbnail sketches

_____ 8. The people in research and development must be able to _____.

A. generate new ideas
B. analyze new ideas
C. communicate new ideas
D. all of the above

_____ 9. A lifelike sketch of a new product is called a _____.

A. rendering
B. thumbnail sketch
C. rough sketch
D. working drawing

_____ 10. A prototype is _____.

A. made before the plans are drawn
B. the first product made according to the plans
C. mass produced on an assembly line
D. a hard mock-up of the proposed product

_____ 11. A hard mock-up of a stereo would not include

A. a tape transport
B. a station dial
C. the internal electronics
D. working switches and knobs

_____ 12. Which of the following can show a design in three dimensions?

A. thumbnail sketches
B. renderings
C. mock-ups
D. working drawings

_____ 13. The first step in the development process is to _____.

A. develop a variety of preliminary designs
B. build and test a prototype
C. develop a set of working drawings
D. develop renderings and mock-ups

_____ 14. The goal of product engineering is to _____.

A. prepare the design for manufacturing
B. discover and gather information
C. design a solution to a problem
D. all of the above

_____ 15. Which of the following communication tools is not used during the design specification process?

A. detailed drawings
B. assembly drawings
C. paste-up mock-ups
D. notes and specifications

_____ 16. Prototypes are built and tested during the _____.

A. development process
B. product engineering process
C. research process
D. brainstorming process

_____ 17. The type of drawing used to communicate the size and shape of a part is called a _____.

A. assembly drawing
B. schematic drawing
C. detailed drawing
D. notes and specifications

_____ 18. The primary reason for conducting a product pre sentation is to _____.

A. convince management to produce the product.
B. sell the product to the public.
C. gather information about the product.
D. test the product.

19. The people in research and development follow a basic series of steps when creating a new product. Put the following list of steps in their correct order by numbering them from 1 to 8.

_____ Make a prototype

_____ Gather information about the problem

_____ Present the new product to management

_____ Select the best solution

_____ Identify and analyze the problem

_____ Test and modify the prototype

_____ Develop a list of possible solutions

_____ Specify the design .

ESTABLISHING A STUDENT ENTERPRISE

Introduction

The economic system of the United States is based on the "free enterprise system," meaning individuals are free to start their own business, produce a product, or provide a service for a profit. Enterprises are companies started by individuals or a group of individuals who are willing to take a risk in order to make a profit (the money left after an enterprise has paid all its expenses). The chance of making a profit encourages people to take risks and establish an enterprise.

One benefit of the free enterprise system is that it allows people to choose from a wide variety of products and services. For example, imagine you are in the cereal section of your local grocery store. How many different types of cereals are there? Because of the free enterprise system, individuals or companies are free to explore and develop different ideas. These ideas can be turned into useful products or services to sell to consumers (one who buys goods) for a profit. This, in turn, provides consumers with a wide variety of products and services. A wide variety of choices creates competition. Competition motivates manufacturers to make a quality product and sell it at a reasonable price.

Ownership in an enterprise can be established through one of three ways: propriatorship, partnership, or corporation. A propriatorship is a company or business totally owned and operated by one person. Examples include businesses such as family farms, individually owned grocery stores, and privately owned service stations. Some of the advantages of a propriatorship are: 1) the owner keeps all profits; 2) the owner has complete control of the business; and 3) the owner can easily start and end the business. Disadvantages include: 1) the owner's liability for all debts; 2) the owner's ability to do all the work; and 3) the owner's difficulty financing the business.

A partnership is a business or company owned and operated by two or more people. A company of this type is easier to finance and the work responsibilities can be divided among the owners. On the other hand, the owners must share profits, they are equally responsible for all debts, and they must agree on all decisions.

A corporation is established through the sale of stock. Some of the advantages are: 1) easier to finance; 2) has its own legal identity; and 3) stockholders have limited liability on debts (i.e., the owners are only liable for the amount they have invested). One disadvantage of a corporation is that government reports must be filed.

This Technology Education Activity will allow students to establish an enterprise by selecting a company name and designing a company logo.

Materials and Supplies

- Chalkboard or overhead projector
- 8 1/2" x 11" sheets of plain paper
- 8 1/2" x 11" x 1/4" grid paper
- Pencils
- Erasers

Problem Statement

All companies are recognized by a company name or logo. A company name or logo can be used to distinguish (to tell the difference) one company or product from another. It is important for your student enterprise to create its own company identity by selecting a name and designing a logo. A company name should:

- be short and simple,
- be easy to read,
- be in good taste,
- represent the company or product, and
- be appropriate for marketing and advertising

Once your company name has been established, then develop a company trademark or logo. A trademark or log is a symbol, group of letters or words that identifies the product and/or represents the company's name, purpose or theme. Can you describe trademarks for companies like McDonalds, Apple Computers, or Chevrolet automobiles? Well designed trademarks and logos are:

- simple and easy to read,
- appropriate for advertising and packaging,
- in good taste, and
- represent the product or company

Activity Procedures

Choosing a Company Name

1. Divide into groups of three. Each group should have several pieces of plain paper and pencils.
2. As a group, develop at least eight to ten ideas for a company that meet the criteria listed in the problem statement.
3. Once all groups have finished their list, have one person from each group share the ideas with the rest of the class. As the ideas are read, they should be written on the chalkboard or on an overhead project.
4. When the groups have shared their ideas, choose the top three names. Make sure each choice meets the criteria listed above.
5. After the top three names have been selected, vote again selecting one. (NOTE: To help prevent peer pressure, this vote should be done by secret ballot).

Designing a Company Trademark or Logo

1. Divide into groups of three. Obtain several pieces of plain paper and a pencil. As a group, brainstorm several logo and trademark ideas. Try to develop designs that are based on your company's name or product.
2. Once your group has generated several ideas, assign one or two to each group member. Obtain several pieces of grid paper.
3. Create a thumbnail sketch for each design idea on the graph paper provided. After all group members have finished, regroup.
4. As a group, evaluate each trademark idea in terms of the design considerations listed in the problem statement.
5. After your group has evaluated each trademark idea, choose the best design.
6. Overnight, have one group member redraw and refine your sketch for presentation purposes.
7. The next day, have one group member present the trademark design to the other students in the company.
8. As a class, vote on which trademark best represents the company.
9. Once a trademark has been selected, it should be redrawn by the marketing department using either traditional graphic arts techniques and drafting instruments or a graphics program and a computer.

Activity Analysis

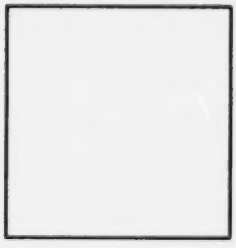
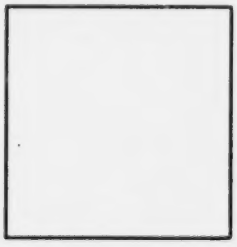
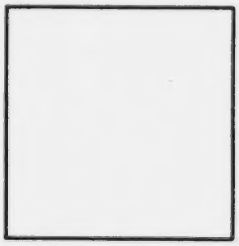
1. List three examples of companies that use letters as their logo or trademark.

_____

_____

_____

2. In the boxes provided below, sketch and label three examples of trademarks or logos which use a graphic or symbols to represent their company or product.

3. What impact can a good name or logo have on the success of an enterprise?

ORGANIZING MANAGEMENT AND LABOR

Introduction

In order for an enterprise to be successful, it must be able to make a product or provide a service which can be sold for a profit. For this to happen, the enterprise must have a good organizational structure. A well organized company relies on two factors. First, the company must have qualified employees to do the work. Secondly, it must have good leadership in order to see that work being completed is done right and is done according to the company's standard. This requires good managers and supervisors. Most companies hire or train people to help supervise and organize workers. These people are part of management. Successful managers must be able to perform four key duties including:

1. Setting up a plan of action which includes establishing goals to meet the company's objectives.

2. Organizing workers, machines, and materials in such a way as to meet the goals while producing a quality product at a competitive cost. This must be done using the fewest processes, machines, and workers.

3. Directing the workers and materials so the company meets its production goals and objectives. Management provides this direction through effective communication, positive motivation, and good supervision.

4. Controlling the progress made toward the company's goals and objectives.

Labor also plays an important role in the success of an enterprise. More and more, companies are updating their facilities with highly automated and sophisticated equipment, and processes. To be successful and competitive in a world market, companies must have a well educated and trained workforce. As the workplace changes, workers of the future will need to possess several key traits, including:

- ability to move from one job to another,
- trainability (being able to be trained for other jobs as needed),
- willingness to continue education,
- higher understanding of mathematics and science principles,
- communication skills (verbal and written),
- ability to follow directions,
- reliability (showing up to work, and on time), and
- ability to work cooperatively

In order for management and labor to work effectively, there must be a "chain of command" established. A company's chain of command is sometimes shown in the form of an organizational chart. SH # 1 shows a sample organizational chart for a small corporation. Notice that the stockholders are at the top of the chart. Stockholders are the true owners of the company and have ultimate control of company matters. Many companies have hundreds of stockholders from all parts of the country or world. This makes it impossible for each stockholder to participate in every decision the company makes. Therefore, the stockholders

select a Board of Directors. The Board forms company policies and provides direction. The Board selects a company president who has direct control of all company activities. The president usually has several vice presidents in charge of major activities within a company. The vice presidents report progress and problems back to the president. The vice presidents must rely on information provided by plant managers. Plant managers have control over the plant or manufacturing facility. Below the plant managers are foremen. A foreman supervises a group of workers on a particular project or process. They see that the work gets done. Finally, the last link in the chain are the workers. The workers are people who accurately run the machines and perform the work established by management. In order for a company to perform efficiently, all levels of authority must work together as a team to achieve company goals.

This Technology Education Activity contains three activities. Students will elect company officials, organize a union, and negotiate a contract.

Materials and Supplies

- Chalkboard or overhead project
- Computer and popular word processing program.

Problem Statement

A company must be organized in order to succeed. This means a company must have people who are reliable, dependable, and organized to oversee company matters. As a company, your class will need to elect the company officers, including a president, and three vice presidents. A vice president will be needed for each of the following areas: marketing, production and financial affairs. Before choosing the company officials, look over the job description and qualifications.

President

The president must be able to relate to people and be a good leader. S/he must be able to provide direction, organize management, and control the progress of the work being done. The president is in charge of running the company. The success or failure of the company is ultimately the responsibility of the president.

Duties:

1. Develop an organizational chart
2. Head negotiations for management
3. Type finalized contract
4. Prepare letters inviting parents, administrators, teachers, and local press
5. Contract school administrators for approval on company matters that involve the school
6. Company spokesperson on the day of the production run
7. Oversee all company activities
8. Responsible for seeing that duties assigned to vice presidents are completed
9. Responsible for grading vice presidents of each department
10. Responsible for final decision in any company matter
11. Write a brief history of the company
12. Write a brief description of the activities of the president

Vice President of Marketing

The vice president must be a creative person. S/he will be in charge of advertising and selling the product, and will be responsible for advertising the day of the production run.

Duties:

1. Oversee
   a. refinement and reproduction of the company logo
   b. design of company name tags
   c. design of ads for selling the product
   d. design of ads to publicize the day of the run
   e. development of a television commercial to advertise the run and the product
   f. development of a display that can be shown in the school's display case
   g. design of product packaging
   h. preparation of instructions on the care and handling of the product
   i. a video tape production showing each step of the production run
   j. coordination and development of a company newsletter, including company history and discussion of activities of each department
   k. distribution of the newsletter
   l. distribution of the products upon completion of the run
2. Write a description of the activities conducted in the marketing department
3. Grade all workers within the marketing department

Vice President of Financial Affairs

The vice president of financial affairs must be a mathematically inclined person. S/he will be in charge of all money-related activities of the company.

Duties:

1. Development of a stock certificate
2. Oversee
   a. printing or reproducing of stock certificates
   b. record keeping of number of stocks sold, to whom they were sold, amount of money the company has, and all purchases of materials and supplies for the company
   c. development of a financial statement showing the financial condition of the company
   d. collection of all money received for stock
3. Write a description of the activities conducted by the financial affairs department
4. Prepare a financial statement that shows the company's worth at the end of the project
5. Grade the workers within the financial affairs department

Vice President of Production

The vice president of production must be a person who is a good planner and has some basic understanding of processing techniques. She/he will be in charge of assigning work areas and setting up materials and equipment in order to produce the product.

Duties:

1. Oversee
   a. prototype analysis
   b. development of a production flow chart
   c. construction of jigs and fixtures
   d. design of a plant layout
   e. development of a safety program
   f. development of a materials handling systems
   g. construction of quality control devices
2. Assign work stations
3. Set up visitor area
4. Write a description of the activities that are involved in the production department
5. Solve problems relating to the dry run
6. Assign a grade to those workers within the production department

Activity Procedures

Organizing Management

1. Take at least three nominations for president.
2. After reviewing the qualifications for president, evaluate the nominees.
3. Using a secret ballot, elect one of the people nominated for president.
4. The president will now conduct the nominations and elections of three vice-presidents. Remember, there should be at least three nominees for each position.
5. After reviewing the qualifications for each vice president, evaluate the candidates.
6. Using a secret ballot, elect one of the three people nominated for each of the three vice presidencies.
7. While the union is being formed, elected management officials should meet and discuss contract issues. This meeting should take place away from the union meeting.

Organizing a Labor Union

Problem Statement

A company's labor force also needs to be organized. The organization typically is in the form of a union, providing labor a "unified voice". A union strives to provide the workers improved working conditions, increased wages, medical benefits, vacation and sick leave. When establishing a union, labor must first elect a shop steward, select a union name, and prepare proposals that can be used in the development of a labor union contract.

Shop Steward:

The shop steward must be able to get along with management as well as fellow workers. The shop steward is the employee's link to management, and management's link to the workers.

Duties:

1. Negotiate for labor
2. Handle any grievances brought about by labor
3. Maintain a path of communication between management and workers

Activity Procedures: Electing a Shop Steward

1. Nominate at least three workers for the position of shop steward
2. Review the qualifications for shop steward and evaluate each nominee for these qualifications
3. Using a secret ballot, elect a shop steward
4. The shop steward should then take charge of the union meeting

Selecting a Union Name

1. Brainstorm various union name ideas, with shop steward writing ideas on the chalkboard
2. Review and evaluate each idea
3. By voting, choose three possible names. Then vote again to choose the final name.

Problem Statement

A union contract is an agreement between management and labor that explains the working conditions, salaries, benefits, job expectations, and responsibilities of both groups. From management's point of view, they want to build the best product for the lowest total cost. From labor's point of view, they want an honest day's pay for an honest day's work. Pay may also include other fringe benefits. Management sees these labor costs as something that is going to increase the total cost of the product. In order for both sides to agree on what is fair, they must negotiate. In your company, the president and the shop steward will be the chief negotiators. In order for a contract to be ratified, it must first be approved by a majority of the employees and employers.

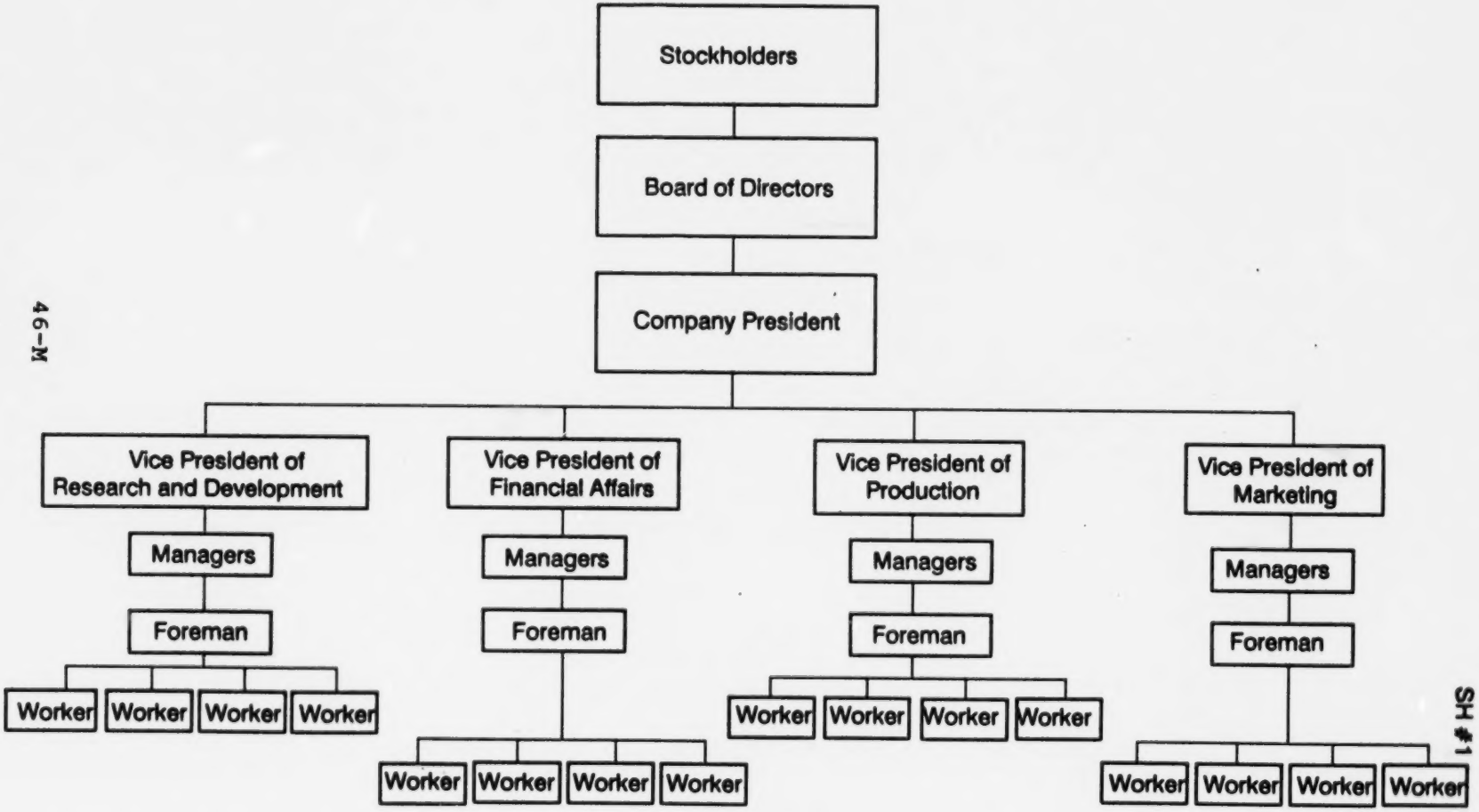
Activity Procedures

Each group should obtain copies of Management/Labor Contract Proposal worksheets (SH #2). With management and labor in separate groups, follow the procedures listed below for negotiating a contract:

1. The management group will brainstorm several contract proposals (SH #2), including worker and management responsibilities, grading, salary, safety, and penalties for not completing work.
2. The labor group will brainstorm contract proposals (SH # 2), including grading policies, salary or reward rates, and overtime or extra work bonuses.
3. Each group should develop a list of proposals. **Do not discuss proposal items with members of the opposite group.**
4. Once both sides have developed a list, the president and shop steward should meet. Points of agreement should be noted along with points of disagreement. The two should try to compromise on points of disagreement.
5. Once proposals have been negotiated by the president and shop steward, the proposals should then be presented to members of each group. Each group should discuss area of disagreement.
6. After a thorough discussion, both groups should vote to either ratify or reject the contract.
7. If rejected, labor will discuss counter proposals and steps necessary to ratify contract. Management will also discuss counter proposals and steps they may take if there is a work stoppage or strike. The two groups will once again meet and present counter proposals for vote.

8. If proposals are again rejected, the two sides will repeat the process.
9. Once the contract is approved, the president will make an official copy and have each employee and management member sign the contract. If possible, the president should use a computer and popular word processing program to create the contract.

SAMPLE ORGANIZATION CHART FOR SMALL COMPANY



46-M

SH #1

MANAGEMENT/LABOR CONTRACT PROPOSAL WORKSEET

Workers' Responsibilities

1. _____
2. _____
3. _____
4. _____

Management Responsibilities

1. _____
2. _____
3. _____
4. _____

Safety Considerations

1. _____
2. _____
3. _____
4. _____

Grading Policies

1. _____
2. _____
3. _____
4. _____

Salaries, Rewards, and Bonuses

1. _____
2. _____
3. _____
4. _____

Penalties

1. _____
2. _____
3. _____
4. _____

Other _____

FINANCING THE ENTERPRISE

Introduction

If a company or enterprise is to begin production of a product or provide a service, it must have money. Money, or capital, is needed to rent or buy a facility, equipment, and materials, to hire workers, and to develop advertising.

Three methods may be used to raise money to finance an enterprise. One is for the owner to use his/her personal capital in hopes of making more money. Another is for the owner to sell stock or part ownership in the company, thus, asking others to invest their capitol. Corporations typically finance an operation in this manner. In exchange, the investors (stockholders) receive part of the profit. The third method is to obtain a loan from a bank or savings and loan company to cover start-up costs.

In this Technology Education Activity, the students will explore the world of enterprise finance by designing, printing, and selling a stock certificates, and keeping sales and expense ledgers.

Materials and Supplies

- Clip arts books, showing various business symbols, borders, and fonts
- Sample stock certificate
- Scissors
- Rubber cement
- If available, it is advised to create the stock certificate using a popular software package (e.g., Certificate Maker, Newsroom, PrintShop, PageMaker) and a computer.

Problem Statement

You are a member of the Financial Affairs Department in a newly established company. Since your enterprise is set up like a corporation, you need to sell stock to raise money. The money received from the sale of stock will be used to purchase materials, supplies, and equipment needed to manufacture the company's product. It is your responsibility to design, print and sell the stock certificate for the company. The stock certificate should provide the following information:

- company's name
- stock number
- share number
- space for the buyer's name
- value of the stock (how much is the stock selling for?)
- spaces for the day, month, and year
- space for the company president's signature
- space for the secretary's signature (in your company, the vice-president of marketing)

Activity Procedures

1. Each group of two should obtain several example stock certificates from the instructor. Carefully study the information presented on each example.
2. Using plain paper, create two or three sketches showing possible stock certificate designs. Remember, each design should include the information provided in the problem statement.
3. Once your group has generated several examples, select one to refine and present.
4. Using either clip art books or a computer and graphics package, develop your sketch into a neater, more refined presentation copy.
5. Once a presentation copy has been completed, present your design idea to the rest of the Financial Affairs Department.
6. The department should then vote on the best design.
7. When one design has been selected, it should be refined further and then reporduced to sell.
8. As the company begins to sell stock, use the "Stockholders and Sales Ledger" sheet (SH #1) to record each transaction. Each transaction should include the date of sale, type of sale, purchaser's address and phone number, the certificate number, number of shares purchased, and the amount paid. This information will be needed to determine if the company made a profit upon completion of this manufacturing experience.
9. The finance department must also keep records of company expenses. As the company begins to purchase materials and supplies to produce the product, a record of each expense should be made (SH #2). It is important to list the description of the purchase, date purchased, cost of each purchase, and the total cost.

Activity Analysis

1. List three examples of companies financed through the sale of stock.

_____

_____

_____

2. What advantage does selling stock have over personal financing when starting a company?

_____

_____

_____

3. Discuss the impact poor recordkeeping could have on the fiscal health of a company.

_____

_____

STOCKHOLDERS AND SALES LEDGER

Date Sold	Type of Sale or Stockholder's Name	Address	Phone #	Certificate #	# of Shares	Amount Paid

COMPANY EXPENSE LEDGER

Date of Purchase	Quantity	Purchase Description	Unit Amount	Total Amount
			TOTAL EXPENSE	

SELECTING AND PLANNING A PRODUCTION SYSTEM

Introduction

Production planning involves analyzing products and deciding the most efficient and cost efficient way to produce it. Production planning is important because poor planning will increase production cost and lower the company's profit.

The first step in production planning is selecting a production system. There are four common types of production systems: custom, intermittent, continuous, and flexible manufacturing.

Custom production is one of the oldest forms of production systems. This type of production is typically used on one of a kind or small volume products. Custom production is commonly done by one highly skilled person who builds a product from beginning to end. In the past, these skilled people specialized in a particular product. For example, a cabinetmaker can custom build cabinets, while a jeweler can make custom jewelry. Now many low volume products like ships, planes, and space craft are produced in this way, using several highly skilled workers. Typically, this type of production is the most expensive production method per number of parts and products made.

As the demand for products grew, so did the demand for a more efficient way of producing products. This demand brought about a production system called intermittent or job-lot production. Intermittent production is used when a limited number of a particular part or product is needed. A manufacturer takes an order from a company or individual, then machinery is set up to produce the product. Once the order is complete, the machinery is modified to produce the next product. As parts are produced, they usually are moved in lots from one machine to the next. The toy and clothing industries both utilize this form of manufacturing.

When large amounts of the same product part are needed, a production system called continuous production can be used. In continuous production (sometimes called an assembly line), a product typically moves along a continuous line. As the product passes by a series of stations, trained workers either add a component to the product or perform an operation. Because a large volume of the same product is being produced, continuous production systems are the most cost effective. This type of production system is commonly used to produce computers, automobiles, televisions, and video tape recorders (VCR's).

As plants become more automated, a new system called flexible manufacturing systems (FMS) is growing in popularity. In a flexible manufacturing system highly automated computer controlled machines are used. The automated machines can be programmed to produce a small volume of a particular product, then can quickly be reprogrammed and set-up to produce a large or small quantity of a different product. This ability to quickly retool to produce different amounts and types of products allows flexible manufacturing systems to produce low volume product lines at low cost.

In order to select an appropriate production method, the first step is to analyze the product, sometimes referred to as prototype or production analysis. Prototype analysis is

used to determine the types of equipment and number of processes needed to make the product. The information is then used to select the easiest, most cost effective way to produce the product. When performing a prototype analysis on each part, graphically show the process needed to produce the part. This can be done using a flow process chart (SH #1). Through prototype analysis, and the development of a flow process chart all the operations, material movements, delays, and storage points can be planned and set up.

This Technology Education Activity contains two production-related activities. Students in the production department will conduct a prototype analysis and complete a flow process chart on the product being produced.

Materials and Supplies

- prototype or sample product
- sample flow process charts (SH #1)
- access to a production lab to see available equipment
- theme paper

Problem Statement

To produce a product in the most efficient manner, a company must select an appropriate production system. This selection process typically begins with an analysis of the product. As a member of the production department, you have been assigned to conduct a product analysis and develop a flow process chart. Based on the information collected, suggest an appropriate production system to the Vice President of Production.

Activity Procedures

1. Obtain a sample product or prototype from your instructor.
2. Analyze each part of the prototype.
3. Determine each process and operation needed to make each part.
4. Determine and list each machine and piece of equipment required to perform the operation. Make sure you list the machine and equipment in the order in which they will be used.
5. Determine and list when and where each part will be moved from one station to another.
6. Determine and list all the critical parts of the product to be inspected. Note where quality control checks should be made.
7. Determine and list where delays may occur during the production run.
8. Determine and list time when materials and parts need to be stored during the production run.

Making a Flow Process Chart

Once the prototype analysis has been completed, the information should be placed in a more graphic and understandable form called a flow process chart. When developing the charts, be sure to create a chart showing a step-by-step sequence of operation for each part of the product.

Design Considerations

The flow process chart should include the following:

1. Material processing operations
2. Material transportation
3. Production inspection
4. Delays during the production run
5. Production storage
6. Identifies special tooling devices
7. Identifies tools and equipment needed to build each part

Activity Procedures

1. Review information collected through the prototype analysis
2. Identify one part of the prototype.
3. Determine the first action (e.g. delay, storage, transportation, operation, inspection) to be performed on the part.
4. Using SH #2, choose and darken the appropriate symbol on the flow process chart (see sample chart SH #1).
5. In the space provided, write a short description of the action (see sample chart SH #1).
6. Next, if appropriate, write the type of machine or tool used and the time required to perform the action. If the part is to be transported, then estimate the distance the part must travel.
7. Review the prototype analysis and determine the second action required to make the part.
8. Choose and darken in the appropriate symbol on the process flowchart.
9. Draw a line from the first symbol to the second.
10. Write a short description of the action.
11. Continue this process until all steps required to manufacture the part are documented.
12. Then, repeat this process for all parts of the product.
13. Be prepared to discuss how the flow process chart was prepared.

Activity Analysis

1. How can the use of flow process charts affect the cost of the product?

_____

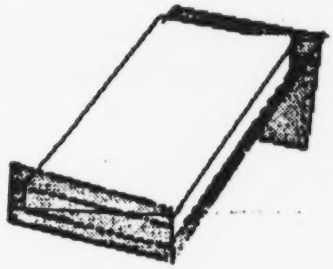
_____

_____

2. Discuss how the information collected on the flow process charts can be used when creating tooling, developing a plant layout and materials handling systems.

3. Discuss how production planning can affect the price of the product.

SAMPLE FLOW PROCESS CHART FOR A MEMO PAD STAND PROJECT



Flow Process Chart

Employee	Product Name: Memo pad stand	Date
Ryan Smith	Part Name: Stand	5/16/99

Process Symbols

○ Operation ⇨ Transportation ▽ Storage D Delay □ Inspection

Operation No.	Process Symbols	Process Description	Machines/ Equipment	Tooling Type
	○⇨▽D□	Remove Plexiglass strips from storage		
	○⇨▽D□	Move to cut off fixture		
1	●⇨▽D□	Cut material to length	Plexiglass cutter	Cut off fixture
	○⇨▽D□	Transport to strip heater		
2	●⇨▽D□	Heat material for first bend	Strip heater	
	○⇨▽D□	Delay until material is heated		
	○⇨▽D□	Transport to bending fixture #1		
3	●⇨▽D□	Bend the material		Bending Fixture #1
	○⇨▽D■	Inspect for cracks		
	○⇨▽D□	Transport to strip heater		
	○⇨▽D□	Delay until material is heated		
4	●⇨▽D□	Heat material for second bend	Strip heater	
	○⇨▽D□	Transport to bending fixture #2		
5	●⇨▽D□	Bend the material		Bending Fixture #2
	○⇨▽D■	Inspect for cracks		
	○⇨▽D□	Transport to finishing station		
6	●⇨▽D□	Glue paper pad to plastic stand		

Flow Process Chart

Employee	Product Name: Memo pad stand	Date
Ryan Smith	Part Name: Stand	5/16/99

Process Symbols

○ Operation ⇨ Transportation ▽ Storage D Delay □ Inspection

Operation No	Process Symbols	Process Description	Machines/ Equipment	Tooling Type
	○⇨▽D■	Final inspection		
	○⇨▽D□	Transport to packaging		
7	●⇨▽D□	Place memo pad and stand into plastic bag		
8	●⇨▽D□	Fasten the label to package	Stapler	
	○⇨▽●□	Delay until final distribution		
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			

56-M

Flow Process Chart

Employee	Product Name:	Date
	Part Name:	

Process Symbols

○ Operation ⇨ Transportation ▽ Storage D Delay □ Inspection

Operation No.	Process Symbols	Process Description	Machines/ Equipment	Tooling Type
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			
	○⇨▽D□			

TOOLING-UP FOR PRODUCTION

Introduction

When producing a product, certain tools and equipment are typically needed to complete the task. The process of preparing and organizing production tools and equipment is called tooling-up. Tool and equipment tooling helps ensure the product is built accurately, produced safely, and the parts are standardized.

More complex products may require special tooling devices in order to achieve accuracy, safety and standardization. These special devices typically fall into five categories: jigs, fixtures, molds, dies, and templates. Jigs and fixtures are used to adapt tools and equipment to perform a certain job. Jigs are used to guide a tool, while fixtures hold the material during an operation. For example, a drilling fixture may be used on a drill press operation. The fixture is attached to the drill press and holds the piece in place during the drilling operation. The drill press bit freely enters the work piece at a determined location. A jig, on the other hand, guides the tool or machine during the process or operation. A self-centering doweling jig, for example, guides the bit into the work piece. Because of the jig, the bit will only enter the work piece at a preset point.

Molds have special cavities where materials like molten metals or plastics are poured. After the material has cooled and set, it takes the shape of the cavity. Many engine blocks and plastic components are made using this technique.

A die is used to shape a part or piece. One type of die is made into a certain shape. Materials are placed over the die. The press is used to shape the materials to the contour of the die. May automobile body parts are formed this way. Other die systems can both cast and shape the piece. This is commonly called die punching. Coins are produced using a die punching technique.

Templates are commonly used during the layout phase of the production process. Template are patterns that can be used to make a certain shape or to locate holes.

Materials and Supplies

- Access to a variety of hand and power tools
- Assorted construction materials (e.g., wood, plywood, plexiglass)
- Graph paper

Problem Statement

Before producing a product, tools and equipment must be set-up and organized. This process is commonly referred to as tooling-up. Many products require special tooling devices. As a member of the products department, it is your job to design, build and test the special tooling devices needed to construct your product. When designing the devices, it is important to remember each device should: 1) improve accuracy, 2) ensure safe operation and 3) make the operation quicker and easier. To ensure this each device should:

- support and/or clamp the work during machining operations,
- locate the work for dimensional control,
- make set up easier,
- perform accurately,
- make the operation easier to perform,
- allow for chip and waste removal when the operation is performed,
- make the operation safer, and
- be constructed with durable material.

Activity Procedures

1. Analyze the prototype parts in terms of the assigned operation.
2. Analyze the machines needed to perform each operation.
3. Using grid paper, sketch ways to guide, secure, and/or locate the part during processing.
4. Once you have designed a special tooling device, evaluate it based on the design considerations listed above.
5. Present your ideas and sketch to the vice president of production and your instructor.
6. Once approved by both the vice president of production and your instructor, obtain the necessary materials and construct the device. (Be sure to obtain permission from your instructor before using any power equipment).
7. Once completed, it is time to test your tooling device. Be sure to obtain permission from your instructors before testing the devices. Through testing, make sure it produces the part safely and according to the product's specifications.
8. Reevaluate the tooling device for the design considerations listed above.
9. Be prepared to explain the purpose and function of your special tooling device. Be sure to identify the safety features built into the device.

Activity Analysis

1. Discuss how tooling devices can affect the cost of a product.

_____

_____

_____

2. List the three main functions of special tooling devices.

_____

_____

_____

3. Discuss the potential negative consequences of poorly designed tooling devices.

ENGINEERING A PRODUCTION FACILITY

Introduction

Three basic engineering considerations need to be taken into account when establishing a new production facility. First, the facility must provide the most efficient use of human, material, and facility resources to eliminate waste. Secondly, a safe work environment must be established. Finally, the facility should be flexible.

In order to eliminate waste, a company must minimize material and personnel movements throughout the facility. To a company, "time is money." If a company's facility has a poor flow of materials, more time is required to produce a product, thus wasting money. Therefore, planning is critical in producing a product in the most efficient manner. One technique is to develop a the plant layout. A plant layout shows the location of machines, transportation paths, position of production personnel, and identifies storage areas within a production facility. The goal is to develop the best possible flow of parts and materials, and provide the most efficient use of production equipment and personnel. This allows a product to be produced using the fewest people, machines, and materials possible in the shortest amount of time.

A key part of a good plant layout is the design of an effective materials and handling system. Fixed path and variable path are two types of material and handling systems. A fixed path system is used when the materials need to move down a single path or line. An automobile, for example, moves down a moving conveyer system and parts and components are added. Some of the devices used in a fixed path system are conveyors, chutes, robots, elevators and overhead chains. A variable path system is used when materials must move freely throughout the facility. For example, materials and supplies taken from storage may need to be delivered at different drop-off points on different days, at different times. It is not cost-effective to run fixed lines to every location throughout a plant. Therefore, devices like carts, hand trucks, fork lifts, automated guided vehicles (AGV), and air bearing vehicles can be used to move materials and upplies freely through a plant.

Safety is another engineer's consideration. Consider the following questions. "What is safety?" Safety is no more than trying to prevent accidents. "What is an accident?" An accident is an unexpected or unplanned injury that results in someone getting hurt or killed. Safety must be a joint effort between management and labor. The owners must provide the workers with a safe working environment, and in turn, the workers must work safely.

Since safety is so important, many companies hire safety engineers to develop a safety program. Safety programs are designed to encourage workers to work safely. Some of the most successful safety programs contain four key elements. The first element deals with the workplace. Tools and equipment must be kept in good working order. This means guards should be in place and working, electrical connections should be checked and the area surrounding the work area should be free of clutter. As far as possible, jigs, fixtures, and processes should be engineered to prevent accidents.

The second element deals with employee training. Workers must be educated to the proper use of the operation of each piece of equipment they use while on the job. Workers

must be taught how to run the machine, load and unload material in and out of the machine, and protect themselves while operating the machine.

The third element deals with safety incentives. It is hard to believe, but in most cases, employees have to be encouraged to work safely. Some companies pay workers or offer rewards and prizes for not getting hurt. Other companies encourage workers through awareness Safety workshops on safety and posters displayed throughout the workplace. Finally, good safety programs must be supported by both management and labor. Workers must know the consequences for unsafe practices and employers must enforce safety rules.

Plant Layout Activity

Problem Statement

A good plant layout allows materials and parts to flow steadily and efficiently throughout the plant facility, thus assuring that time is not wasted. A good plant layout is important in the development of your product as well. Remember, "Time is money." As a member of the Production Department it is up to you to study the company's product and develop a plant layout. A plant layout should include the following elements:

1. Location of all machines and equipment, work benches, walls, doors, windows, storage rooms, and personnel
2. Lines showing the paths of each part as it moves through the facility from one station to the next
3. A safe working environment
4. The movement of materials and personnel must be minimized.

Activity Procedures

1. The vice president will choose one or two workers to develop a plant layout.
2. After studying the product and flow process chart, analyze the production lab facility.
3. Use 1/4" grid paper to draw a basic floor plan of the laboratory.
4. Using SH #1, cut out templates for the benches, machines, and equipment found in the laboratory, and operator templates for each employee. (Be sure to only include machines found in your lab. Also, some templates may have to be created to represent equipment not found on SH #1, e.g., surface planers, machine lathes).
5. Fasten the templates for those machines which cannot be moved.
6. Lay out but **do not fasten down** the remaining templates on the graph paper. Using the flow process chart as a guide, position machines and equipment in different locations. Follow the path of each part and experiment with the sequence of operations.
7. When you feel you have the best layout, fasten the remaining templates to the graph paper.
8. Locate each operator in a safety zone and fasten operator templates in place.
9. Using different colored markers, show movement of each part from one station to another.
10. Present your plant layout proposal to the vice president of production. He will gain approval of the design from the president and instructor.
11. After gaining approval, use the plant layout as a guide to set up the laboratory.

Materials-Handling Activity

Problem Statement

To create a smooth flow during the production run, a materials handling system should be developed. The system must be able to move the needed parts and materials from one station to another quickly and efficiently. As a member of the Production Department, it is up to you to design, build, and test a material handling system for the company. Consider the following:

1. Should a fixed path system be used?
   a. conveyors
   b. chutes
   c. robots
   d. elevator
   e. overhead chains
   f. automated guided vehicles
2. Should a variable path system be used?
   a. hand trucks
   b. carts
   c. fork lifts
   d. air bearing vehicles
3. Have the material handling devices been constructed safely?
4. Does the system allow for a smooth flow of parts and materials?
5. Will the system deliver each part or subassembly to the proper location at the right time?

Activity Procedures

1. The vice president will choose one or two people to develop a materials-handling system.
2. Review the different types of materials-handling systems tested above (e.g., conveyors, robots, hand trucks, carts).
3. Use the plant layout and flow process charts to identify places where parts must move from one station to the next. Then, determine an appropriate materials-handling system for each transportation problem identified. Be sure each design follows the considerations found in the problem statement.
4. Using graph paper, sketch possible designs of material handling devices, identifying where each device is to be used.
5. Once you have designed the devices, present the proposed system to the vice president of production.
6. Once approved, obtain the material needed to construct the devices. **Safety Note: Be sure to obtain permission from your instructor before using any power tools or equipment.**
7. Construct the devices and set them in the proper location.
8. Have the vice president of production and the instructor check the finished product for design and safety.
9. Test the efficiency of the devices.

Safety Program Activity

Problem Statement

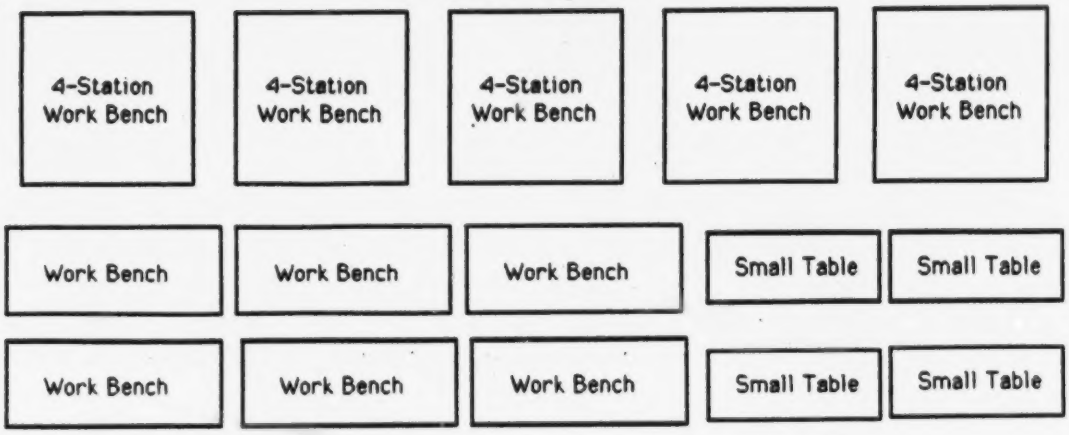
Safety is a key factor in the success of any company. Work can not be completed if workers are hurt on the job. To provide a safe working environment, a safety program must be developed. As a member of the Production Department, it is your job to develop a safety

Development Procedures

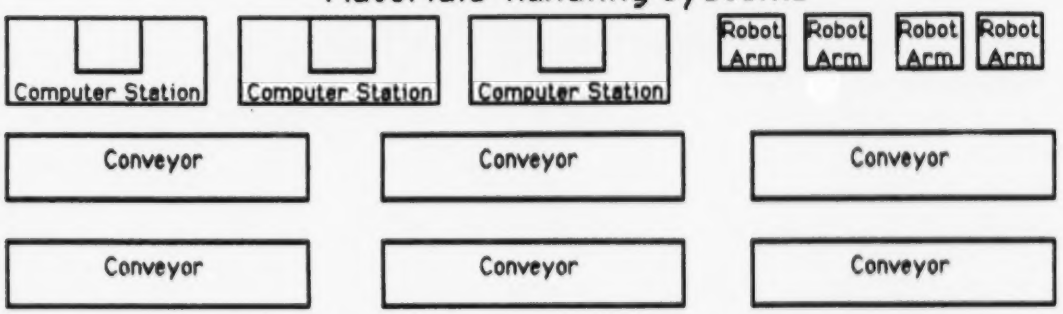
1. The vice president of production will choose one or two people to develop a safety program.
2. Develop a list of all workers, machines, and equipment needed to produce the company's product.
3. Brainstorm a list of areas to be included in the safety program. Be sure to include areas like personal, general, and machine and equipment safety practices. Develop policies and procedures for each of these areas and then train students in the procedures.
4. Using the Training Progress Chart (SH #2), trace the worker's progress. The chart lists each worker, equipment, test results, and date of completion. The company president and instructor should initial the chart showing when a worker has completed the training.
5. Inspect all jigs and fixtures. They should be designed and engineered so accidents are virtually impossible. For example, fingers should not come close to dangerous cutting edges or blades. Workers should be located so they do not bump into each other, etc.
6. To provide safety awareness, create signs and posters identifying hazardous work areas. Once signs and posters have been created, display.

Sample Plant Layout Templetes

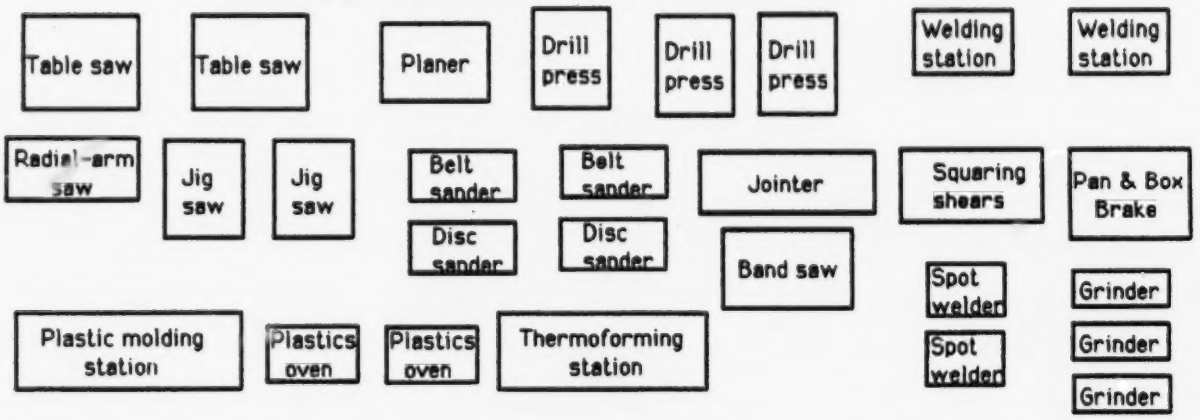
Work Space



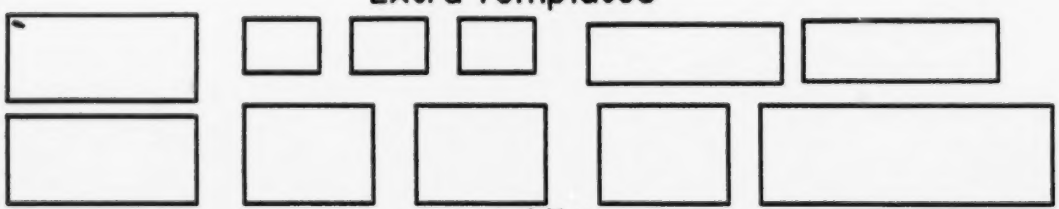
Materials-handling Systems



Machine and Equipment Templates



Extra Templates



TRAINING PROGRESS CHART

Worker's Name				
Machine/Equipment	Test Results	Date Completed	Instr. Int.	Pres. Int.

STATISTICAL PROCESS AND QUALITY CONTROL

Introduction

Quality control is considered the use of techniques and activities to achieve, maintain, and improve the level of excellence of a product or service. The role of quality control is to see that the product is manufactured properly and works as it was designed to work. Quality is not perfect. Quality does not mean that every product is totally free of defects. A company that would produce a 100 percent defect-free product would find its product priced out of the market. Quality means meeting defined standards. These standards are determined by the product's end use (e.g., the standard for a shuttle component would be much higher than for an inexpensive toy).

Two techniques used to improve and monitor the quality of products and services are statistical process control and statistical quality control. Statistical process control applies statistical techniques to the **process** used to make a product or service. In other words, statistical process control tries to build quality into the product **before** it becomes a finished product. Highly automated equipment and computers are usually used to monitor all processes. For example, with a computerized milling machine, the milling process can be monitored and controlled in such a way that if a tool begins to wear, the milling machine will adjust itself in order to maintain a consistent cut, thus, insuring a quality product.

If you were to buy five products from a certain company and four of the products had to be returned because of a defective part, would you buy more products from that company? Of course not! As a consumer, you demand a certain quality (the fitness of a product) in the products you buy. A manufacturer must provide you, the consumer, a quality product at a reasonable price. Several American companies have lost business to foreign competition because they failed to produce a quality product at a reasonable price. All successful companies use a method called "quality control" to produce a quality product.

When you look at a product, let's say a car, what does quality mean? You would want a car that has a good finish on the body, a finish that won't fade or get dull or change its color, or crack. Your idea of quality would mean that the engine performs the way it should; it would start easily, run smoothly at all speeds, would not guzzle too much gas, would not use oil, and so on. You would expect that the doors would fit properly without large gaps, and would open and close easily. You would expect everything to work the way it is supposed to work. Windows should work, dashboard signal lights and gauges should function properly, the lights and turn signals should work, etc. To make sure that the car you buy has the quality that you expect, the manufacturer must practice quality control.

Statistical quality control includes the collection, analysis, and interpretation of data for use in quality control activities. Simply stated, statistical quality control is in knowing statistically, "what is the size of the pieces" and "how much do they differ." This technique is used to check the quality of the **finished** product. The product is inspected with aid of gauges and measuring instruments. Inspection devices such as go/no gauges can be used to check whether or not a part is cut to the right length. If the piece is too long, it will not fit in the gauge or if the piece is too short, it will fit too loosely.

The process of statistical quality control involves taking a small sample from a much larger population and then using statistical methods to determine if the product or service is within a given tolerance. Basic statistical procedures including calculating the mean, range, and standard deviation can be used to determine the variance in parts. To make the information easier to visualize and understand, the data is usually displayed in the form of a histogram.

This Technology Education Activity will provide students with the opportunity to use the statistical procedures of calculating the mean, range, and standard deviation and to create a simple frequency histogram.

Note: This activity can be taught as a "stand alone" activity, but it is most meaningful to students when integrated into a manufacturing activity.

Materials and Supplies

Equip each quality control team with:

- a micrometer or vernier caliper
- calculator
- at least twenty like-components to make a sample (e.g., 1" pieces of 1/8" dowel rod, 1/2" nuts, 16d nails)

STATISTICAL QUALITY CONTROL ACTIVITY

Problem Statement

Your student enterprise is manufacturing a product. In order for the product to sell, it is very important to maintain a high standard of quality. As a member of the production engineering department, it is your job to check the quality of the components leaving the plant. Since it is impossible to check every component produced each day, samples will be selected and checked. After selecting a sample of a part or component, your department vice president wants you to calculate the mean, range, and standard deviation. The vice president of Production has requested your team to check the quality of the two components and report your findings. He/she wants your team to answer the following questions.

- What is the average size of the components?
- How much does the average size of the component differ from the mean?
- What is the overall difference in the size of all the components?

He/she has also requested that all data collected be reported in a graphic form with all calculations plotted.

Activity Procedures

Before beginning, the Vice President, President and Instructor should set a standard for the part or components to be checked. A standard sets limits or tolerances on the allowable variation in a part's size. A 1/2: hex nut, for example, may be a little bigger or smaller than 1/2" due to the production process. Standards describe the allowable tolerances. Components for the space shuttle may have very tight tolerances, while, toy components may have lower tolerances.

1. In order to answer the first question, "What is the average size of the components?", the team will need to collect and record data. Then the mean can be calculated. To accomplish this, each team will need to obtain a sample of 20 components, a micrometer or a vernier caliper, and a calculator.
2. The next step is to measure each component and record your findings in the second column of SH #1. **(NOTE: Complete the following steps for each part or piece separately. In other words, calculate all information for one part or complenent before calcluating the other.)** Using a micrometer or a vernier caliper, one team member should collect the measurements, while the other member records the data and places the components into small piles, with each pile representing components of equal size. Be sure to keep track of the numerical values each pile represents. **ALSO, BE SURE TO RECORD YOUR DATA ACCURATELY.**

This illustration below shows the data collected for 1/2" hex nuts.

n = number of measurements
x = individual measurements

(n)	(x)	-	$(\bar{x})$	=	$(x-\bar{x})$	$(x-\bar{x})^2$
1	.559					
2	.560					
3	.564					
4	.559					
5	.564					
ETC.						
22	.562					
23	.563					
24	.562					
25	.563					

3. Once your team has collected the data on SH #1, calculate the mean. Record your answer in column three.

VERY CAREFULLY add all 20 measurements found in column 2 (x).
****MAKE SURE YOU CHECK YOUR ANSWER****

PLEASE WRITE YOUR ANSWERS ON A PIECE OF SCRAP PAPER.

What was the total? _____

Next, divide the total from above by 20. You use 20 because that is how many individual measurements you recorded.

sum of (x) _____ divided by (20) = Number of measurements (n) _____

Check your answer

Place the mean in every space in the third column of your SH #1. This column is labeled ($\bar{x}$). Refer to the illustration below.

$\bar{x}$ = mean = sum of the individual measurements

number of measurements

Illustration

mean = $\frac{14.055}{25}$

mean = .5622

(n)	(x)	-	($\bar{x}$)	=	($x-\bar{x}$)	($x-\bar{x}$)^2
1	.559		.5622			
2	.560		.5622			
3	.564		.5622			
4	.559		.5622			
5	.564		.5622			
ETC.						
22	.562		.5622			
23	.563		.5622			
24	.562		.5622			
25	.563		.5622			
totals	14.055					

5. After your group has calculated the mean ($\bar{x}$), there are two more columns left on the handout. This information is needed in order to answer the second question, "How much does the average size of the component differ from the mean?" This question must be answered by calculating the standard deviation. To calculate the standard deviation, the last two columns must be completed. The fourth column is determined by subtracting the mean ($\bar{x}$) from the individual measurement (x). The goal is to determine the difference between an individual measurement and the mean. This is represented by the symbol ($x-\bar{x}$) on your chart.

For example, the illustration below shows .559 as the actual measurement of the first component and the mean is .5622. To calculate the deviation of individual measurements ($x-\bar{x}$), subtract .5622 from .559. The answer is -.0032. This number is found in column four. Notice that some of the measurements are positive and some of the measurements are negative. If x is less than $\bar{x}$, the number will be negative. **Be sure to indicate on your data sheet whether or not the number is positive or negative**

($x-\bar{x}$) = The difference between an individual measurement and the average.

Illustration

(n)	(x)	- ($\bar{x}$)	= ($x-\bar{x}$)	($x-\bar{x}$)^2
1	.559	.5622	-.0032	
2	.560	.5622	-.0022	
3	.564	.5622	+.0018	
4	.559	.5622	-.0032	
5	.564	.5622	+.0018	
- - -

6. Once your group has completed column four $(x-\bar{x})$, the next step is to calculate the data for the last column. This column is calculated by squaring the individual measurements in the fourth column $(x-\bar{x})$. This is done to eliminate the negative values found in column four. The illustration below shows $(x-\bar{x})$ to be -.0032 for the first component. To calculate $(x-\bar{x})^2$, take -.0032 squared. (-.0032 x -.0032 = .0000102)

$(x-\bar{x})^2$ = The difference between an individual measurement and the average squared.

Illustration

(n)	(x)	-	$(\bar{x})$	=	$(x-\bar{x})$	$(x-\bar{x})^2$
1	.559		.5622		-.0032	.0000102
2	.560		.5622		-.0022	.0000048
3	.564		.5622		+.0018	.0000048
4	.559		.5622		-.0032	.0000102
5	.564		.5622		+.0018	.0000048
ETC.						
22	.562		.5622		-.0002	.0000006
23	.563		.5622		+.0008	.0000006
24	.562		.5622		-.0002	.0000006
25	.563		.5622		+.0008	.0000006
totals	14.055					

7. The next step is to add up all the numbers found in the fifth column and place the total at the bottom. This total will be used to calculate the standard deviation. **MAKE SURE YOU CHECK YOUR WORK.**

This example shows a completed chart.

(n)	(x)	-	$(\bar{x})$	=	$(x-\bar{x})$	$(x-\bar{x})^2$
1	.559		.5622		-.0032	.0000102
2	.560		.5622		-.0022	.0000048
3	.564		.5622		+.0018	.0000048
4	.559		.5622		-.0032	.0000102
5	.564		.5622		+.0018	.0000048
6	.564		.5622		+.0018	.0000048
7	.565		.5622		+.0030	.0000102
8	.564		.5622		+.0018	.0000048
9	.565		.5622		+.0030	.0000102
10	.563		.5622		+.0008	.0000006
11	.563		.5622		+.0008	.0000006
12	.559		.5622		-.0032	.0000102
13	.562		.5622		-.0002	.0000006
14	.564		.5622		+.0018	.0000048
15	.563		.5622		+.0008	.0000006
16	.562		.5622		-.0002	.0000006
17	.559		.5622		-.0032	.0000102
18	.564		.5622		+.0018	.0000048
19	.562		.5622		-.0002	.0000006
20	.558		.5622		-.0042	.0000176
21	.562		.5622		-.0002	.0000006
22	.562		.5622		-.0002	.0000006
23	.563		.5622		+.0008	.0000006
24	.562		.5622		-.0002	.0000006
25	.563		.5622		+.0008	.0000006
totals	14.055				total	.000119

Data collected above shows the diameter of twenty-five 1/2" hex nuts

8. When your team has completed the chart, the next step is to calculate the standard deviation. For example, the standard deviation for the chart above is .002. This was calculated by:

$$\text{Standard Deviation} = \sqrt{\frac{\text{Sum of } (x-\bar{x})^2}{\text{The number of observations} - 1}}$$

$$SD = \sqrt{\frac{\text{Sum of } (x-\bar{x})^2}{n-1}}$$

$$SD = \sqrt{\frac{.000119}{25-1}}$$

$$SD = \sqrt{\frac{.000119}{24}}$$

$$SD = \sqrt{.0000049}$$

$$SD = .0022135$$

This number can be rounded to the nearest thousandth.

This would make the standard deviation .002.

SD = .002

Calculate the standard deviation for your data.

$$\text{Standard Deviation} = \sqrt{\frac{\text{Sum of } (x-\bar{x})^2}{\text{The number of observation} - 1}}$$

$$SD = \sqrt{\frac{\text{Sum of } (x-\bar{x})^2}{n-1}}$$

Subtract 1 from the total observation.

$$SD = \sqrt{\frac{}{20 - 1}}$$

Divide the top number by the bottom number

$$SD = \sqrt{\frac{}{}}$$

Take the square root

$$SD = \sqrt{}$$

$$SD =$$

NOTE: If needed, be sure to round off the number.

9. In order to answer the third question, "What is the maximum difference in the size of the components?," your team will need to calculate the range. Use the process shown below to calculate the range of your components.
Look through the list of measurements (found in column x on your chart) and find the largest number. What is the largest number _____?
Look through the list of measurements and find the smallest number. What is the smallest number _____?
Largest number minus smallest number = range (R)
_____ - _____ = _____

10. Now that your team has successfully calculated the standard deviation and the range, it is time to put your data in a graphic form. Begin by labeling the histogram found on SH #2. By looking at your team's chart, place each different measurement starting with the smallest on the left and ending with the largest on the right across the bottom. Make the divisions equal, **BEING SURE TO INCLUDE ALL POTENTIAL MEASUREMENTS, EVEN THOSE THAT DID NOT CONTAIN COMPONENTS.** See the sample histogram on next page.

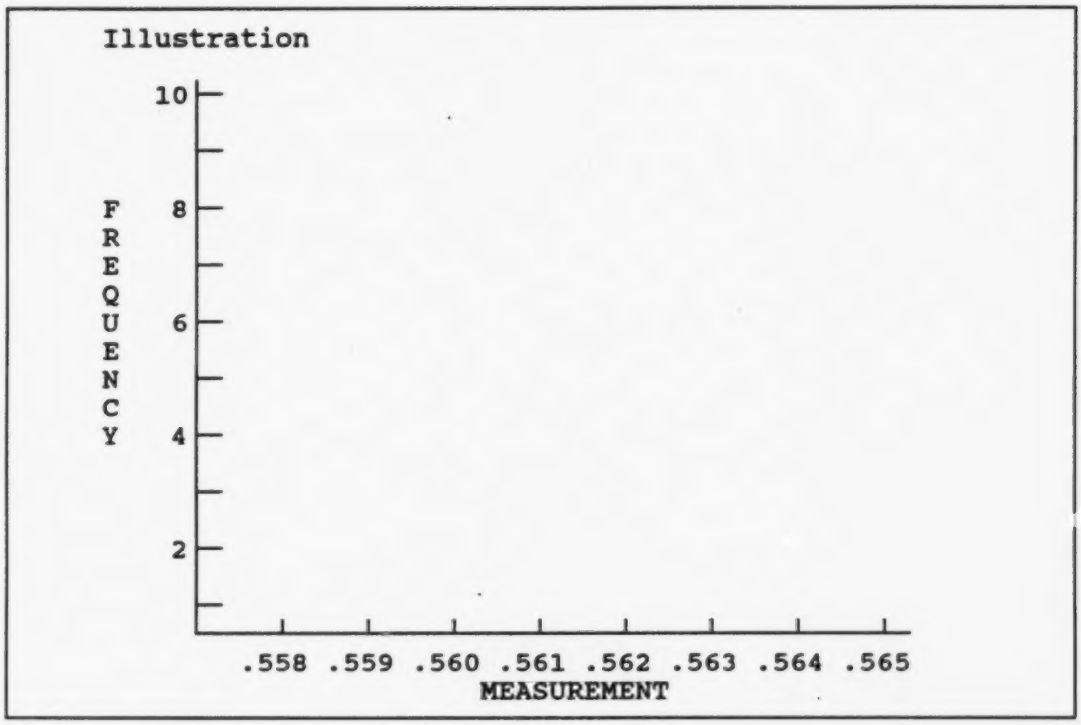
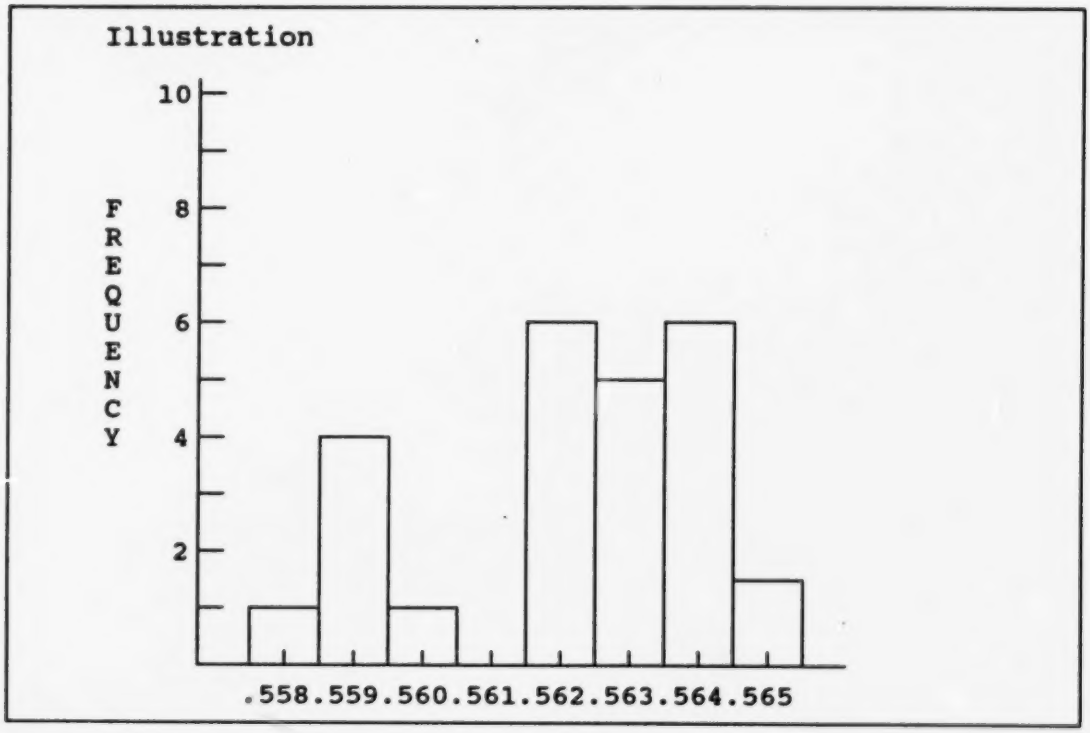
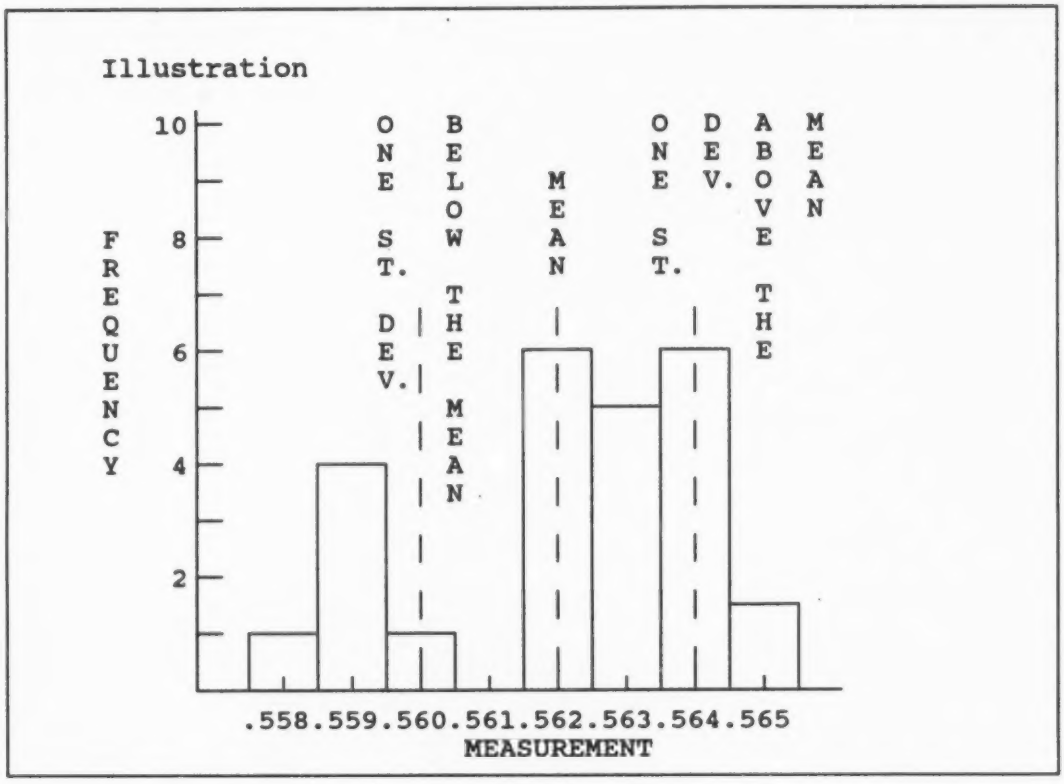


Illustration
10
8
6
4
2
FREQUENCY
.558 .559 .560 .561 .562 .563 .564 .565
MEASUREMENT

Next, count and plot the number of components for each column on your histogram (see illustration below).



12. Finally, locate the mean and standard deviation on the graph. Below is a completed histogram showing the frequency, mean, and standard deviation for data found in figure 1.



Activity Analysis

1. Discuss how the information on the histogram compares to the standards given at the beginning of this activity.

   _____

   _____

   _____

2. Those parts that do not meet the standard are considered _____.

   A. Waste
   B. Finish parts
   C. Tolerances
   D. Deviation

3. Based on the information found on the Histogram, how can you improve the quality of your product?

   _____

   _____

   _____

STATISTICAL QUALITY CONTROL WORKSHEET

*(n)	**(x)	- ***($\bar{x}$)	= ****(x-$\bar{x}$)	*****(x-$\bar{x}$)2
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				
13				
14				
15				
16				
17				
18				
19				
20				
Totals				

* n = number of measurements

** x = individual measurements

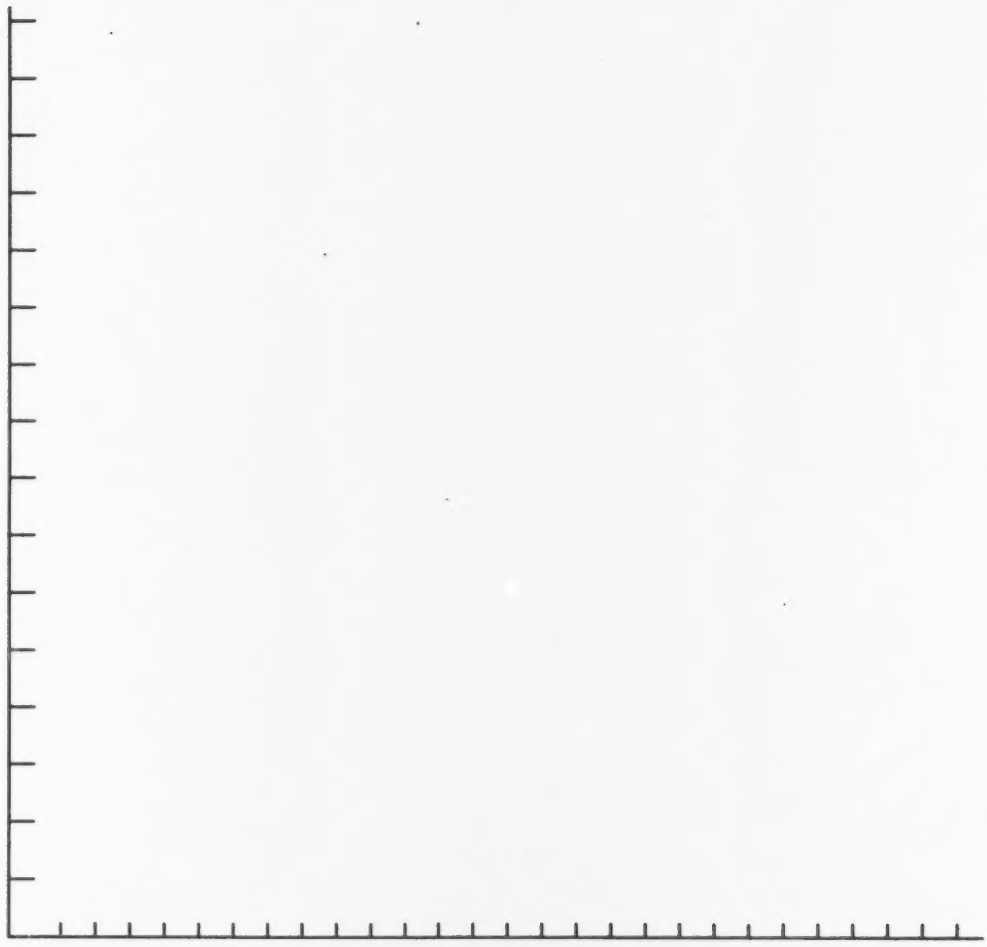
*** $\bar{x}$ = mean = Sum of the individual measurements / number of measurements

**** (x-$\bar{x}$) = The difference between an individual measurement and the average.

***** $(x-\bar{x})^2$ = The difference between an individual measurement and the average squared.

SH #2

STUDENT HISTOGRAM WORKSHEET



PREPARING TO MANUFACTURE THE PRODUCT

Introduction

Once a company has planned and prepared the facility, equipment and workers, it is time to produce the product. In order to determine whether or not all the "bugs" are worked out of the production system, most companies conduct a dry run. The dry run includes building a product from the beginning to end. This allows the company to test all the processes used in making the product. Once completed, the company can identify any problems, correct them, and then begin production. This refining process helps to reduce defective parts and waste.

After all the checking and rechecking, it is time to produce the product. Typically, a product goes through three phases during the production process. First of all, the parts and components of the product must be made. Some automobiles, for example, may have the side panels produced in the plant. Secondly, a group of parts are put together to form subassemblies. In the case of an automobile, engine blocks are subassembled. Finally, the parts and subassemblies are fit together to make a finished product.

As the production process moves through each phase, three areas must be controlled. These include quality, inventory and labor. Quality can be controlled with the use of inspections. First, materials should be inspected before they are used. This will help eliminate defective materials from becoming part of the manufacturing process. This must be followed up by periodic inspections done throughout the entire production process. This will help insure good workmanship. Finally, the final product should be inspected to insure the product is free of defects and has maintained the desired level of quality.

The second consideration is inventory control. There must be some system of tracking the number of products being produced and material being used. If this is not done, material shortage could occur. This could cause production delays.

Finally, labor must be controlled. Labor must be checked to see if they are performing up to the standards of the company. In other words, workers must do quality work.

Problem Statement

The time has come to build your product. Before starting the final run, it is a good idea to have a practice or dry run. This will help identify and fix problems before the final production run.

Activity Procedures

1. It is the vice president and shop steward's responsibility to:
   a. assign work stations.
   b. to see each worker receives the proper training to perform their work assignment safely and efficiently.

2. It is the workers' responsibility to:
   a. check that all guards and other safety devices are in place and working properly.
   b. check that he/she has all the materials and equipment needed to perform the work.
   c. test each machine, tool, and special tooling device to see if they are working properly.
   d. report any problems immediately to the vice president of production and the instructor.
   e. perform the work to the best of his/her ability.
3. Once each operation has been checked, conduct a trial run. During the first run, produce one product. In doing so, major problems can be identified and corrected.
4. After conducting a trial run and making modifications, conduct a second trial run. During the second run, three products should be made consecutively. This will help identify "bottle necks" in the production process. More stations or tooling devices may be needed to balance the line.
5. Once all problems have been solved, produce the desired number of products.

Activity Analysis

1. Explain the reason for conducting trial runs.

_____

_____

_____

2. What problem areas were identified during your dry run?

_____

_____

_____

3. How did your student company control for:

   A. quality _____

   _____

   B. inventory _____

   _____

   C. worker skill _____

   _____

MARKETING THE PRODUCT

Introduction

Once produced, a product must then be marketed. Marketing is necessary to identify potential customers, and is used to promote, distribute and sell the product. Potential customers can be identified through market research. Through market research, a company hopes to learn the answers to such questions as:

- Who will buy the product?
- How many people will buy the product?
- How much will people pay for the product?
- How will people use the product?
- How should the product be advertised?
- What changes should be made in the product?
- What do people like about the product?

The answers to these questions can be obtained through a market survey. The survey is commonly conducted through phone or personal interviews. Typically, market research is done early in the design process. Once gathered, the information is used to forecast possible markets. If the research shows people are not going to buy the product then the company has two options, either to change the product or stop further development.

Once a product has been produced, then marketing assumes several other responsibilities. One such responsibility falls in the area of packaging. Packaging provides:

- protection for the product
- displays the product
- makes the product easier to handle and ship
- identifies the product
- attracts consumer's attention
- provides information about the product.

Often the product is produced and packaged, then the potential customers must be made aware the product is available. This is done through advertising. Advertising, is used to:

- attract the consumer's attention
- inform the consumer about the product
- persuade the consumer to purchase the product
- cause the consumer to act on purchasing the product

There are several ways to advertise. One form, newspaper advertising, is relatively inexpensive and provides consumers with printed copy as a reference. On the other hand, a disadvantage to newspaper advertising uses only one of our senses, sight. Newspaper ads typically must compete with many other ads. If the ad is not placed in a prominent position in the newspaper, the ad may never be seen.

Radio is another method of advertising, utilizing the sense of hearing. Radio advertising is relatively inexpensive and reaches a large audience. On the other hand, consumers must own a radio and have it tuned in at the time of the advertisement. As in newspaper advertising, there is a great deal of competition for the radio market. Each advertiser wants their ad to air during the most popular show.

Television offers another avenue for advertising, using the senses of sight and hearing.Television also has the potential to reach a large audience. However, television advertising is expensive. And, like radio, potential consumers must own a television and have it turned on when the commercial is aired. Television advertisers spend a lot of time targeting their audience. For example, the commercial shown during Saturday morning cartoons are targeted for younger audiences, whereas, the commercials shown during the local and national news are developed for an older clientele.

Other forms of advertising include billboards, signs on buses, trains, and buildings, and sales flyers.

Finally, marketing is responsible for distribution and sales. A product is made available to the consumer through direct or indirect distribution. Through direct distribution, a consumer may purchase the product directly from the manufacturer. Indirect distribution requires the consumer to purchase the product from a retailer. The distribution process includes transporting the product from the manufacturer to the consumer. Transportation can be done by plane, car, train, truck, or pipelines. Once the product has been distributed to retail stores, the consumer exchanges money for the product, thus completing the sales process.

Packaging the Product

Materials and Supplies

- Construction paper
- Poster board
- Various sizes of clear plastic bags
- Optional: a computer, printer, paper, and popular graphic software packages (e.g., Print Shop, Newsroom, Publish It)

Problem Statement

Most products produced today require some type of packaging. Packaging is used to protect, hold, and market the product. The vice president of marketing has assigned you the task of designing an appropriate package for your company's product.

Activity Procedure

1. The vice president of marketing will select one or two students to design an appropriate package for the company's product.
2. After reviewing the role of packaging stated above, analyze the product in terms of its packaging needs.

3. Design a container for the product, using inexpensive material (e.g., plastic freezer bags, poster board). Each package should be
   - simple and easy to read
   - in good taste
   - representative of the product
4. Each design should provide information such as the company name, address, contents, product description, and price. A computer and popular graphic software package can be used to enhance the package design.
5. Once the designs are complete, present them to the vice president of marketing. He/she will discuss the design with the president and instructor.
6. Once the packaging design has been approved, develop a system for mass producing the packaging.

Activity Analysis

1. What is the potential impact of well designed packaging?

_____

_____

_____

2. List two packaging techniques used by companies to protect products.

_____

_____

_____

3. List two packaging techniques used by companies to display products.

_____

_____

Advertising the Product

Materials and Supplies

- Paper
- Marker
- Clip art
- OPTIONAL: A computer, printer, and popular graphic software package

Problem Statement

Advertising is used to inform the public you have a product to sell. As a member of the Marketing Department, you are in charge of developing advertising. The vice president of your

company has assigned you the task of designing advertising for a new product. The ads should be in the form of a poster or flier. Each layout should include:

- headlines and captions
- catchy phrase or slogan
- pictures and/or clip art
- company name and/or trademark
- information about the product (e.g., cost, care instructions)

The graphic design should have:

- balance
- rhythm
- contrast
- unity
- proportion

Activity Procedures

1. The vice president of marketing will select one or two students to develop posters and other graphic advertisements.
2. Begin by drawing several sketches illustrating possible poster layouts. Keep the sketches small and simple. Each design should be:
   - simple and easy to read
   - in good taste
   - representative of the product
3. From the sketches, select the best design or combine several good ideas into a new one. The rough sketch should be larger and include more detail. Develop your ideas into the form of a rough sketch.
4. Once a graphic as been developed, write a message that describes your product. Keep in mind the design considerations listed above.
5. Present the rough sketch to the vice president of marketing for approval.
6. Gather the materials needed and make the final layout. The vice president will share the design with the president and instructor. Add any changes made by them.
7. Present the final layout to the vice president of marketing for approval. Once approved, duplicate and distribute.

NOTE: Posters may be produced using a computer and a popular graphic software program (e.g., Print Shop). Computer clip art could also be included. Small print can be accomplished by using a typewriter. Then, cut and paste into place, along with captions and/or photographs.

Activity Analysis

1. What impact could poor advertising have on the company?

_____

_____

_____

2. List three methods used to advertise products.

_____

_____

_____

3. List the advantages and disadvantages of each method listed in Question 2.

	Method of Advertising	Advantage
a.	_____	_____
		_____
		_____
		Disadvantage
		_____
		_____
		_____
	Method of Advertising	Advantage
b.	_____	_____
		_____
		_____
		Disadvantage
		_____
		_____
		_____
	Method of Advertising	Advantage
c.	_____	_____
		_____
		_____
		Disadvantage
		_____
		_____
		_____

CLOSING THE STUDENT ENTERPRISE

Introduction

The success of a company is measured by whether or not it is profitable. To determine this, accurate financial records must be maintained. To accurately determine the financial health of a company, records of overhead, personnel costs, inventory, and purchasing must be maintained. Two factors used to determine profit include costs and income. The total cost is determined by the company's direct and indirect costs. Direct costs include the cost of paying the production workers and materials used to produce the product. Indirect costs include the cost of paying non-production employees, equipment, office supplies, facility maintenance, marketing and taxes. Income is the money made through the sale of products, buildings, equipment, tools, waste materials, and services. Profit is the money left after the compnay pays all of its expenses. A company's profits can fall into two categories: gross profit and net profit. Gross profit is the total profit after the company pays all expenses before texes. Net profit is the profit (money) the company keeps after taxes. This money can be kept by the owner (if single proprietership or partner), or paid as dividends to stockholders. The money may also be put back into the company.

Major companies determine their financial status through yearly or annual reports. Annual reports commonly include balance sheets which show the company's assets and liabilities. Assets represent the company holdings that can be converted into money or cash. Liabilities represent the debts owed by the company. Typically, the annual report will also include an income statement. The statement defines the company's income, outlines the company's costs and expenses, shows profit before taxes, and states the net profit. Annual reports are used to establish company objectives and goals for the coming year.

If a company decides to go out of business, certain procedures must be followed. These procedures typically include:

- filing documents with state and local agencies
- terminating employees
- converting all assets to cash
- pay all outstanding debts (e.g., taxes, legal costs, employees, creditors, and stockholders)

In this Technology Education Activity, students will determine their student company's financial status. In order for this activity to be successful, the expense ledgers and sales ledgers from the Financial Affairs Department must be completed before this activity.

Problem Statement

Now that your student company is coming to an end, it is time to find out its financial health. To determine the success or failure of your company, an income statement must be completed.

Activity Procedures

1. The vice president of financial affairs will select a student to prepare a final report.
2. Using the expense ledger, calculate the company's expenses.
3. Using the sales ledger (completed as part of the "Financing the Enterprise" activity), determine the total income of your company.
4. Using the information found on the sales and company expense ledgers (also prepared in an earlier activity), prepare a profit/loss statement.
5. Using the information found on the sales and company expense ledgers, prepare a profit/loss statement (SH #1).
6. Did the company make a net profit?
7. Finally, prepare a report and present it to the company.

Activity Analysis

1. Explain how financial statements and reports can be used for long term product planning.

_____

_____

_____

2. Discuss how poor record keeping could impact a company.

_____

_____

_____

PROFIT/LOSS STATEMENT

Revenue:

Income:

Sales of products and stock	**$**	_____
Sales of material inventory	**$**	_____
Other Income	**$**	_____
Total Revenue	**$**	_____

Expenses

Direct Cost:

- Raw materials _____
- Production lab _____

Indirect Cost:

- Lab materials _____
- Advertising _____
- Labor _____
- Maintenance _____
- Equipment _____
- Other costs _____

	Total Revenue	_____
-	Total Cost and Expenses	_____
=	Gross Profit	_____
-	Taxes	_____
=	Net Profit	_____

SERVICING

SERVICING

Suggested Learning Objectives

Upon completion of the servicing unit, students will be able to:

A. Identify basic **applications** for servicing technology including installing systems; repairing mechanical and electric components; and maintaining consumer and industrial products.

B. Define and properly use common servicing **terminology** like estimate, bid, installation, repair, product liability, trouble shoot, and work order.

C. Describe the basic servicing **processes** like installing, repairing, adjusting, modifying, replacing, salvaging, maintaining, diagnosing, and estimating.

D. Describe the social and environmental **impacts** associated with servicing activities including the recycling and disposing of defective components and products; the trend toward a service-based economy; and consumer fraud. SC2

E. Describe the basic human, material, natural, informational, financial, and technological **resources** associated with servicing processes and enterprises (e.g., test equipment, product specifications transportation).

F. Describe the major milestones in the **history** and evolution of servicing technology including the introduction of trades, use of computerized trouble shooting technologies, and development of consumer protection agencies. SS2

G. Identify potential **safety** hazards, establish guidelines for safe behavior, and adhere to common safety practices when around or participating in servicing activities. PH3

H. Identify, describe, and evaluate **career** opportunities in servicing (e.g., service technicians, industrial trouble shooters, and carpet installers) based on their interests, talents, and career expectations.

I. Describe the basic attributes of service organizations such as: work performed close to the customer, workers do not produce a product, service can not be stored, customers pay mostly for labor, and companies tend to be small.

J. Discriminate between industrial service and personal service.

K. Determine the tools, materials, and processes needed to address a given servicing problem.

L. Use common problem solving techniques to trouble shoot and service a simple mechanical, electrical, fluid power, and/or thermal system.

M. Determine the best solution to a servicing problem based on cost, safety, material, consumer, labor, liability, and ethical considerations.

N. Describe the communication considerations associated with servicing activities including providing accurate estimates, answering service calls, documenting the services rendered, and billing customers.

O. Analyze the ethical issue associated with servicing activities including liability, consumer protection, and warranties.

P. Forecast the potential effects of a service-based economy on things like unemployment, small businesses, and international trade. SS1

Suggested Learning Experiences

1. Introduce students to the concept of servicing mechanical devices. Using common commercial or teacher prepared service manuals, have a small group of students trouble shoot a small engine. Possible teacher-installed bugs could include things like defective spark plugs, broken head gaskets, closed needle valves, and/or clogged fuel lines. Using a real or teacher-made work order, have students document the work performed, labor costs, part costs, and total cost of servicing their assigned engine. Ask the students how preventive maintenance can prolong machine and equipment life. Discuss the importance of documenting services and their cost.

2. Discuss the communication tools used to describe or illustrate the procedures used to service various products. Have small groups of students analyze a simple electrical device and develop a flow chart and/or service manual for trouble shooting and servicing the circuit. Make sure the flow charts or service manuals feature procedures for diagnosing and replacing things like defective wires, switches, bulbs, and/or batteries. Ask students to evaluate the advantages and disadvantages of using graphic versus written procedures or servicing a product.

3. Introduce the students to the concept of trouble shooting. Using common commercial or teacher prepared service manuals, have small groups of students trouble shoot and service a microcomputer. Possible teacher-installed bugs could include things like removing the interface card, using defective software, adjusting the disk drive speed, installing defective cables, and/or altering monitor adjustments. Have students analyze the ethical issues associated with servicing consumer and industrial products.

4. Explain the difference between production and service organizations. Discuss the relationships between the two types of organizations and their customers, the types of work performed, and what the customer purchases. Establish a student enterprise that sells, installs, and services burglar alarms. Identify a name for the new company and appoint service managers and technicians. Ask students how the trend toward a service-based economy will effect their educational needs, career options, consumer practices, and quality of life.

5. Discuss the role and importance of training in service industries. While playing the role of a manufacturer's representative, conduct training sessions on installing, trouble shooting, and servicing simple alarm systems. Discuss how some occupations require service technicians to take a certification examination. Require students to take and pass a test on the content taught during the training sessions before they are allowed to participate in subsequent activities. Ask students to discuss why service industries need trained service technicians.

6. Discuss the practices used in the service industry to assess customers' needs and provide estimates. Provide each student a scenario describing the features a customer would like in their alarm system (e.g., panic switch, key locations, number of windows protected). Have each team report to a mock-up of a house featuring working doors and windows. Ask each team to determine the components needed to fulfill the customer's requirements. Using a teacher- developed form, have each team complete an estimate describing the work that needs to be performed, the materials required, and how much the project will cost. Discuss the consumer's right to an accurate estimate versus the service agency's need for flexibility in the event of unexpected expenses.

7. Introduce students to the concept of installation. Provide each service team a work order describing a given customer's needs based on the information gathered during the activity above. Using things like magnetic switches, pin switches, key switches, buzzers, and relays, have students install an alarm system onto their assigned mock-up. Make sure each alarm system works and is installed properly. Have each team complete and submit a bill for the services rendered. The bill should document the work performed, material used, labor costs, material costs, taxes, and total cost. Ask students to describe the consequences of not installing products correctly on a company's reputation, profit, customer relations, and future sales.

8. Provide each service team a work order for a service call. Each work order needs to describe the customer's complaint based on a teacher-installed bug. Possible bugs could include things like defective connections, wires, switches, batteries, and buzzers. Using the work order as a guide, have each service team identify the tools, materials, and replacement parts needed to service the alarm system. When they are ready, have each team report to the mock-up corresponding to the service call and service the alarm system so it works according to specifications. Have each team complete and submit a bill for the services rendered. Ask students to identify the characteristics of a professional service technician (e.g., appearance, skills, courtesy).

9. Discuss the milestones in the history and evolution of servicing. Assign each student a historical event. Using library resources, have students gather information and develop an abstract describing the people, dates, places, and impacts associated with their assigned event. Encourage students to illustrate their abstracts. Post each abstract on a large timeline. Ask students to describe how given events influenced our culture and subsequent technological developments.

10. Discuss the career opportunities in servicing systems. Include occupations at the non-skilled, semi-skilled, skilled, technician, and professional levels in the discussion. Using library and guidance resources, have students gather information and present a short written or verbal report about an occupation related to servicing systems. Each report should include information about the educational requirements, working conditions, benefits, salary, and advancement potential related to the occupation. Ask students to evaluate the career based on their interests, talents, and career expectations.

SERVICING

Overview

Introduction:

Doing work for the benefit of others is called service. Most of the time, service is performed in exchange for payment. Service is so important in today's society that sixty-eight percent (68%) of all workers are employed in service jobs. Two out of every three workers are employed in service jobs and only one out of three workers is employed in goods producing jobs. Service will continue to be important. Jobs in the service industries will increase faster than jobs in the goods producing industries.

There are four reasons why service jobs will increase in importance. First, raw materials and energy are becoming scarce. As a result, the price of new goods will increase. It will be cheaper to maintain and repair old goods than to buy new ones. People will spend more money on repair and maintenance and buy fewer new items. We can no longer throw away broken and worn out goods. We must place more emphasis upon repair and maintenance.

The second reason why service will be more important is due to rising incomes. People will have more money to spend on health care, leisure and school. These are services that will increase as people earn more money. Therefore, as people have more money to spend, they are likely to spend it on services.

The third reason why service will be more important is due to an improved standard of living. This refers to the amount of money people will spend on durable goods and leisure. People will buy more durable goods such as bicycles and television sets. Services will be needed to get these items to the consumer and also to repair and maintain them. Also most leisure time activities require service workers to repair, maintain and manage the goods and property used in leisure activities. Therefore, as the standard of living increases so will the need for services.

Service is difficult to automate. This is the fourth reason why service will be important. Some services such as the automatic car wash or a candy vending machine are services that have been automated. Many services have not been automated. In contrast, many manufacturing jobs have been automated and people have been replaced by machines. This has not been the case with many service jobs. Therefore, the need for service jobs will most likely increase in the future.

Types of Service:

Service may be of two types: industrial service and personal service. Industrial service is the work that maintains or improves goods. Personal service is the work that maintains or improves the well-being of people. Industrial service, therefore, maintains products while personal service applies to people. Examples of personal services may be in such areas as care, public transportation, recreation, banking and insurance. Such areas as bicycle repair, auto mechanics, building upkeep, appliance installation and airplane mechanics are good examples of industrial services.

Industrial Service:

Industrial service is work that maintains or improves goods. This is done by installing, maintaining, and repairing. In order for the service to be profitable, the service must be delivered by trained individuals at a reasonable cost (estimate). This is accomplished by one or more of five service processes: diagnosing, adjusting, replacing, modifying, and salvaging.

Diagnosing:

The first and last step to industrial service is diagnosis. When a good is to be serviced by installing, maintaining or repairing, the worker must first determine what is to be done. Many industrial service workers believe that figuring out the problem is half the work. The last step to industrial service is also diagnosis. The worker inspects the good to determine that the work was done correctly. At times, a service worker can diagnose a problem very easily. Other times this is more difficult. The worker will often study a repair manual or diagram (drawing) of the product and use the technological method when diagnosing a problem. The six steps to technological method are:

* define the problem or opportunity
* gather resources (information, testing equipment, etc.)
* form and prioritize solutions
* test the solutions as needed
* determine consequences for a solution(s)
* select and implement solution

Diagnosis by the technological method can save much time and effort. Also, customers get very upset when they pay good money for service and find out that the good is still in need of service. Another benefit of proper diagnosis before industrial service begins is that the customer can be told what the cost will be for parts and labor. The worker will also know how much time is needed for each job and what tools, materials and parts are needed. It is important to remember that diagnosis is the first and last process of industrial service. Diagnosis is done to determine what must be done. Diagnosis is also done to determine if the work was done properly. A service worker must often make decisions about installing, repairing, maintaining and discarding of goods. A service worker who makes the right decision by using the industrial service process of diagnosis will be in high demand by employers and customers.

Adjusting:

Often goods or property are in need of adjustments. The industrial service worker must change or move parts so the item performs like it is supposed to. Gapping spark plugs or setting a door stop are examples of adjustments to goods. Sometimes adjustments may be made when new parts are installed or maintained. Adjustments are also made to repair an item that is not working properly.

Often a part will be ruined or wear out because it was not adjusted properly. As you can see, adjustment is a very important service function to install, maintain and repair goods.

Replacing:

We have all experienced times when parts were lost, worn out or broken. The good or property can be serviced by replacing the old part with a new, used or modified one. Replacing of parts is most often done when goods are repaired. Goods are also replaced when maintenance is performed. Changing oil in a car, for example, is a maintenance service in which the old oil is replaced with new oil. Replacement is not often thought of when installation service is performed. There are, however, times when goods or property are replaced as a result of installation. For example, when an air conditioner is installed, the existing electrical service may be replaced to meet the added electrical needs. Also, a door, roof or window may be removed so a large machine can be brought in a building to be installed. In this case, the door, roof or window must be replaced as a result of the installation of a machine.

Modifying:

When goods are installed, maintained or repaired, parts are changed to improve or add value to them. A good is modified when small or partial changes are made. In construction, we refer to modifying as remodeling. In manufacturing, modifying is sometimes called rebuilding. Modifying will become more important in the future as inflation continues and raw materials become scarce.

Salvaging:

When goods are saved from a complete loss, they are salvaged. Perhaps you are familiar with an automobile junk yard. Cars are cut up and stored until they are sold for scrap metal or replacement parts. The term "recycle" has become popular as a word that refers to salvage. This is also growing as an important service because of scarce raw materials and as a way to clean up our environment.

Service Organizations:

Some day, you might have to deal with a service company as a customer or as an employee. Perhaps you might even own your own service company. You should know more about how and why service companies operate.

Services are offered to the customer for many different reasons. A manufacturing or construction company, for example, may provide a service to promote the sales of their product. "We service what we sell" is a good marketing slogan. These companies provide a service in the form of a guarantee. They guarantee that their product will be of high quality and will be depe dable. This type of service is offered to keep the product working properly and the customer happy. The satisfied customers will usually do repeat business and tell their friends about the company. These companies provide the service as part of marketing.

Other companies are in business to provide a service. They hope to make a profit by providing a service for the customer. Many service companies are small in size. In your town, there are many small businesses that provide only a service. Can you name some of the small service companies? Other service companies are very large. The telephone company is an

example of a large company that provides a service. Most manufacturing companies require lots of capital (land, money and machines) to produce a product. These goods producing companies have many levels of managers.

In contrast, many service companies are small and do not have as many levels of managers. There are many exceptions to this, one such exception is the telephone company. Since most goods producing companies are large and most service companies are small, the difference is worth noting. You could start a service company with very little capital. Lawn mowing, small engine repair and a gas station are examples of small business companies that provide a service. Would you like to own your own service company? It is important to remember that a service company, large or small, must involve all the elements of a goods producing company.

Attributes of Service:

Operating a service company or service division within a company involves many of the same tasks as operating a goods producing company. Accurate records, for example, must be kept and money must be available to pay bills. Providing a service is similar to producing a good. There are, however, five attributes that are unique to service.

1. Service work is done close to the customer.

   First and most important, a service is often performed close to the consumer. A service worker often goes to the customer's home or business to perform the work. Can you imagine taking a refrigerator to a store for repair? Part of the service in fixing a refrigerator is traveling to the customer. The travel time to and from the customer is part of the service charge. Some things are small enough, or are mobile and can be transported to a central location for service. A toaster or car are examples of this. Even then the service worker often comes in contact with the customer. In comparison, people seldom come in contact with the workers while they make a car or build a building. Think about other appliances or items that cannot be brought in for service.

2. Service workers do not produce a product.

   Service workers do not make a product. They may install, maintain, repair or discard a good or they may perform work that benefits people, but this work does not result in producing a product. In contrast, a goods producing worker makes a product.

3. A service can not be stored for future use.

   A good can be produced and then stored (inventoried) until it is needed. A service can not be stored. A tire, for example, can be changed before it goes flat, but changing a tire can not be stored until the time it is needed. If your furnace does not work, you can not go to a shelf and get the stored repair for it. Even with a good preventive maintenance program, repairs will still be needed. A worker can not do maintenance work ahead of the time that it is needed. Therefore, the industrial service elements of install, maintain, and repair can not be performed

and stored before they are needed. Service is consumed as it is produced. This causes scheduling problems unique to service. Workers are often paid to stand by in case a service is needed. Other times, when a service is in high demand, the customer must wait a long time for service.

4. The customer often pays mostly for labor.

When a service is performed, the customer pays for the skill, knowledge and time required to perform the task. Often the customer pays for parts or supplies needed to perform the service, but most of what the customer pays for is labor. When a good is bought, you pay for the raw materials, labor and expensive machines used to make it. Some services are being automated, but most services still involve more labor cost than materials and machines. Therefore, when a service is performed, the customer most often pays mostly for labor.

5. Most service companies are small.

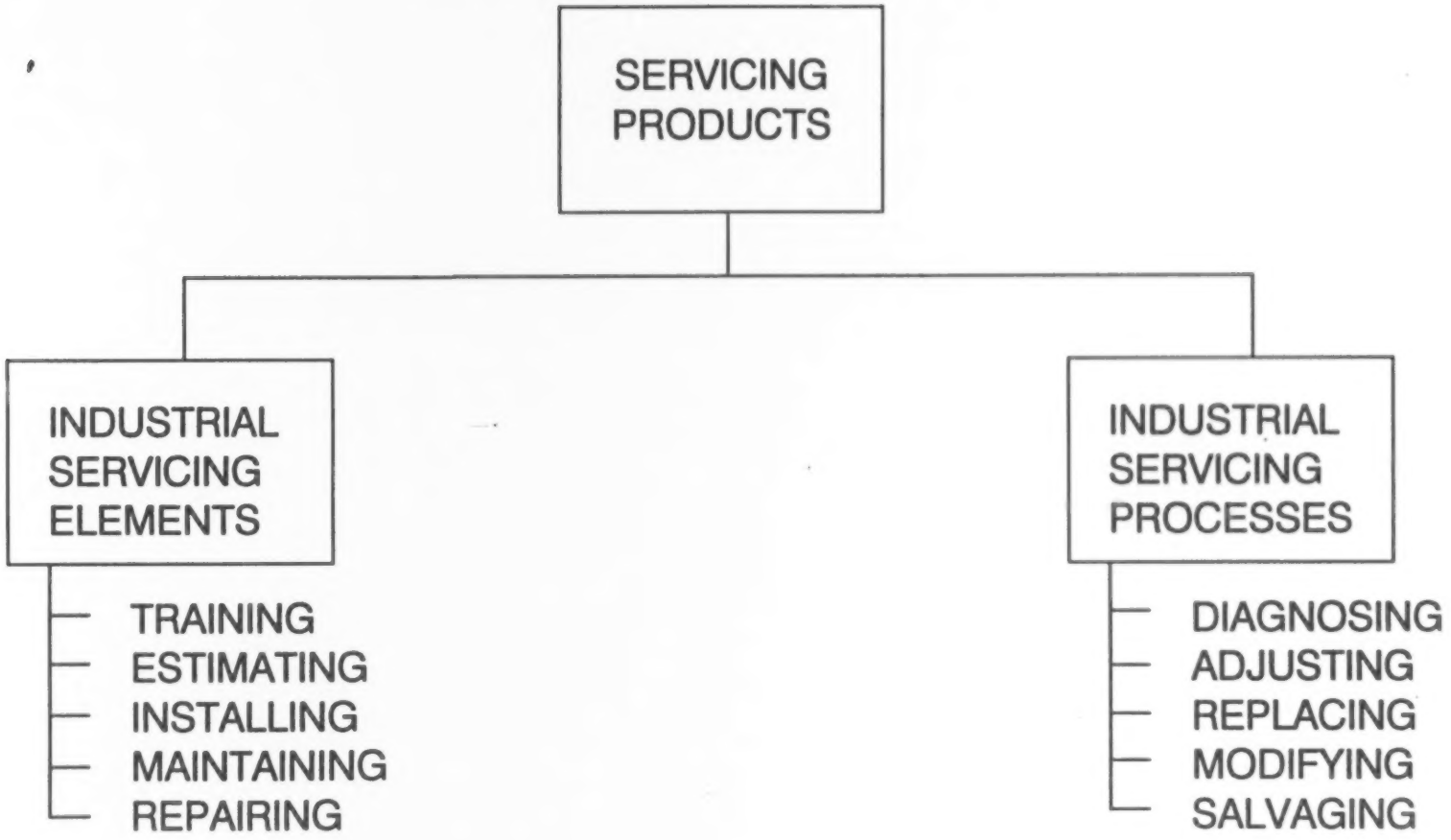
Most service companies are small. They employ a few workers and do not require large buildings such as factories. Some services, such as the utilities and government, are exceptions to this. They are very large and complex organizations. Most service companies, however, are very small when compared to manufacturing companies. There are many small service companies and very few large ones.

Bundle of Benefits:

We learned earlier that there are two types of industries: 1) those that make goods, and 2) those that provide a service. Today most goods producing industries are also involved in performing a service. John Deere and IBM, for example, both produce goods. But they also employ many service workers to maintain the machines and buildings used to produce the product. They also employ many other workers to perform the service for the customer after the product has been sold. Most goods producing companies, therefore, produce a good as well as provide a service. These companies provide a bundle of benefits that include producing a good, as well as providing a service. In fact, almost all purchases you make include paying for a good as well as a service.

Service is an important part of our society. More than 68% of the nation's workers are employed in service jobs. Reasons for growth in the number of service occupations include scarce raw materials and energy, raising incomes, improved standard of living, and difficulty in automating service jobs. The two basic types of service are industrial service and personal service. Industrial service involves work that maintains or improves goods. Personal service is work that maintains or improves the well being of people. The three basic elements of industrial service are installing, maintaining, and repairing. The five industrial servicing processes are diagnosing, adjusting, replacing, modifying, and salvaging.

This series of Technology Education Activities will allow students hands-on experiences with each phase of servicing.


SERVICING PRODUCTS
INDUSTRIAL SERVICING ELEMENTS
TRAINING
ESTIMATING
INSTALLING
MAINTAINING
REPAIRING
INDUSTRIAL SERVICING PROCESSES
DIAGNOSING
ADJUSTING
REPLACING
MODIFYING
SALVAGING

SERVICING
Training

Introduction

As goods and products become more advanced, the need for highly trained service technicians increases. In order for service technicians to stay up-to-date with the advances, they must undergo constant training and retraining. Training is the method used to provide people with the skills and knowledge necessary to perform their current job duties efficiently and effectively. For example, someone who installs air conditioners must first be trained on the proper tools, safety practices, and setup techniques required to complete the installation properly. If the type of air conditioners being installed changes, then the installer may need to undergo retraining.

There are basically three types of training programs: in-house, out-of-house, or a combination of both. With in-house training, employees receive training from a program usually developed and conducted within the organization. Typically, safety programs are conducted in-house. Out-of-house programs are developed and conducted outside the organization, and conducted through consultants, technical school, college, or university instructors. Courses like air conditioner repair and small engine maintenance are examples of out-of-house training. With a combination training program, training may be developed outside the organization but delivered on-site, or the materials can be developed inside the organization and conducted at a local college.

In this Technology Education Activity, student will simulate the training process by participating in an in-house training program.

Materials and Supplies

Each group of two students should be equipped with the following materials:

- Volt meter
- 9 volt battery
- 9 volt battery snap connector with leads
- 100 k ohm variable resistor (potentiometer)
- 2N2222 transistor
- Heavy-duty SPST slide switch
- Piezo electric buzzer
- 2 1" #6 pan head screws
- 2 3/4" long pieces of plastic hose (to be used as spacers for the switch)
- 12 1/2" #6 pan head screws
- 2 12" long pieces of wire, size AWG 18-26
- 2 3" long pieces of wire, size AWG 18-26
- 1 6" x 3 1/2" x 3/4" piece of wood
- 1 magnetic burglar alarm switch (switch closed when magnet engaged)
- 9V battery holder (snap-in type)
- 1 6-volt relay
- Scissors
- Soldering gun

- Solder
- Solderless spade tongue terminals to fit wire size listed above
- Crimping tool for use with spade tongue terminals
- Screwdriver
- 9 #6 Washers
- Hot melt glue gun and glue

Problem Statement

ICU Security Systems is a small business in the resort community of Lake Brook. In the process of encouraging local development, many economic benefits have been realized by the community. Some negative impacts have been realized because of the expansion, such as an increase in crimes like vandalism and home invasion. As a result, citizens have begun to take steps to protect their homes and property. ICU Security Systems is expanding to meet the demands for home and business security systems and will need trained technicians. An in-house training program has been developed for new employees. As a new employee, you will participate in the company's training program.

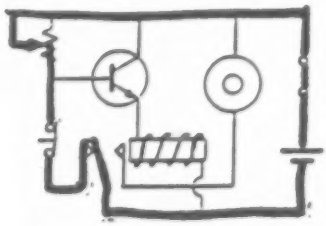
Activity Procedure

1. Obtain the required materials (see list) and ICU Security Systems Training Manual (SH #1).
2. Using the training manual and materials, assemble the alarm system.
3. Once assembled, test the system.

Activity Analysis

ANALYZING THE MODEL T-78 CONTROLLER UNIT

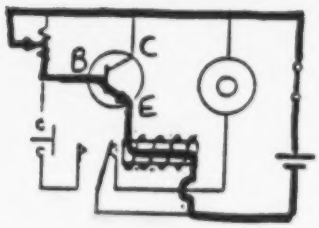
1. Now that the system's controller unit is assembled, let's look at how it works. When the unit is turned on, current flows from the battery through the normally closed relay contacts, the magnet switch, the variable resistor, the slide switch, and back to the battery (see illustration below).



2. With the slide switch in the off position and the magnetic switch closed, measure the controller unit's current. (NOTE: Have your instructor show you how to use the meter before testing current.) Touch the positive test lead to the screw labeled S1. Touch the negative lead to the screw labeled S2. Read the meter and record the current in the space below.

_____ milliamps

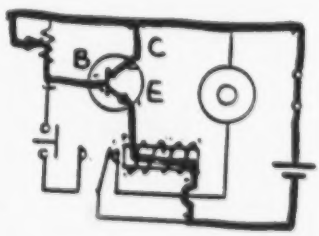
3. When the magnet is moved away from the magnetic switch, the switch opens and the current path is broken. The current from the battery must find a new path back to the battery. Therefore, current flows from the battery through the relay coil, into the emitter lead of the transistor, out the base lead of the transistor, through the variable resistor, through the slide switch, and back to the battery (see illustration below).



4. Will this new current path cause the alarm to sound? Don't worry if you do not know the answer. Circle your best guess.

A. Yes
B. No

5. The answer to the question above is yes and no. Technically, the new current path does not drive the piezo buzzer. The current flowing through the new circuit is not strong enough to close the relay. However, the current flowing through the emitter to the base of the transistor is strong enough to allow current to flow through the emitter to the collector (see illustration below).



The current flowing through the emitter to the base is a small force controlling a large force. The large force is the current flowing through the emitter to the collector. It is strong enough to create a magnetic field around the relay coil and move the contact. Let's test this idea. Remove the wire conductor between the screws labeled B and T1. Move the slide switch to the on position. Touch the end of the positive test lead to the screw labeled T1. Touch the end of the negative lead to the screw labeled B. The alarm should sound. Read the meter and record the current in the space provided below.

_____ milliamps

6. Move the slide switch to the off position. Reinstall the wire conductor between the screws labeled E and the screw labeled T1. Disconnect the relay lead from under the screw labeled E. Measure the current between the relay lead and the screw labeled E. Move the slide switch to its on position. Touch the end of the positive lead to the screw labeled E. Touch the end of the negative test lead to the wire conductor coming from the relay. The alarm should sound. Read the meter and record the current in the space below.

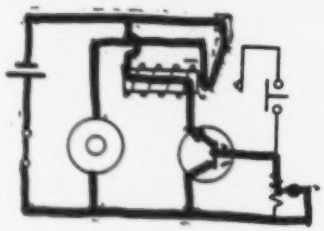
_____ milliamps

7. The current flowing into the transistor's emitter is ____ the current flowing through its base. Circle the best answer.

A. greater than
B. equal to
C. less than

8. Move the slide switch to its off position and reinstall the relay lead under the screw labeled E.

9. When the transistor triggers the relay, the movable contact disconnects the magnetic switch. In the process, it connects the battery to the piezo buzzer. Not only is current flowing through the relay and the transistor, current is now flowing through the relay to the piezo buzzer (see illustration below).



Needless to say, this current causes the piezo buzzer to sound.

10. Measure the total current flowing when the alarm is sounding. Make sure the magnet is touching the magnetic switch. With the slide switch in the off position and the magnetic switch closed, measure the current between S1 and S2. Touch the end of the positive test lead to screw labeled S1. Touch the end of the negative lead to the screw labeled S2. Move the magnet away from the magnet switch while watching the meter. Read the meter and record the current in the space below.

_____ milliamps

11. Total current in the circuit _____ when the alarm is tripped. Circle the best answer.

A. decreases
B. stays the same
C. increases

ICU TRAINING MANUAL

Model T-78 Alarm System
Controller Unit Assembly

STEP 1

Before beginning the assembly process, several components will need wire conductors soldered to them. Locate the relay, slide switch, and 100 K variable resistors. (NOTE: Be sure to check with your instructor before using the soldering gun.) Carefully solder one 1 1/2" wire conductor to each of the five posts on the bottom of the relay (see illustration A below). Next, solder a 1 1/2" wire conductor to each of the two posts on the bottom of the slide switch (see illustration B below). Finally, solder a wire conductor to the center post and the front right post of the 100 K variable resistor (see illustration C below).

A B C

In order to ensure reliable connections, use the crimping tool to crip a spade tongue solderless terminal to the end of each wire conductor used on the alarm controller unit (see "'ustration below).

STEP2

Spread a thin film of glue on the top of your block of wood. Using a pair of scissors, cut out the template found on DR #1, place the template on the block of wood so the border of the drawing lines up with the edges of the wood. Smooth the air bubbles from underneath the template and allow it to dry for a few minutes. Trim the excess paper around the edges of your wood block.

STEP 3

Use a 1/16" twist drill to make 1/2" deep pilot holes at each of the locations marked by a circle on the template. Drive a 1/2" #6 pan head screw with washer 1/4" into each pilot hole in the template which was marked by a darkened circle.

Find the location for the transistor on the template. Bend the transistor leads VERY carefully so they touch the screws labeled C, B, E. Place the transistor in its location with the flat side facing down (see DR #2). The collector lead should be under the screw labeled C. The base lead should be under the screw labeled B. Lastly, the emitter lead should be under the screw labeled E. Carefully loop each lead clockwise around their screws. No two leads should touch each other.

Find the location for the variable resistor on the template. Obtain the 100 K variable resistor. Place the resistor in its location with the dial face up. (see DR #2). Place one lead terminal under the screw labeled C. Place the other lead terminal under the screw labeled T1. Now position the dial on the variable resistor so its arrow is in the 10 o'clock position.

Install a 3" long wire conductor between the screw labeled B and the screw labeled T1 (see DR #2).

Find the location for the slide switch on the template. Using one inch screws and spacers, mount the slide switch in its location (see DR #2). Place one lead terminal under the screw labeled S1. Place the other lead terminal under the screw labeled S2.

Find the location for the relay on the template. (NOTE: It is convenient to mount the relay upside down.) Place the normally closed contact lead terminal under the screw labeled T2 (see DR #2). Place the movable contact lead terminal under the screw labeled MC. Place one coil lead terminal under the screw labeled E. (NOTE: Depending on the style of relay used, the installation of the relay may vary.)

Using two 1/2" #6 pan head screws, mount the piezo electric buzzer in its location. Attach solderless spade tongue terminals to the end of both leads. Place the positive lead terminal under the screw labeled S1. Place the negative lead terminal under the screw labeled NO.

Install a 3" long wire conductor between the screw labeled S1 and the screw labeled C. Before installing, be sure solderless spade tongue terminals have been attached to each end.

STEP 11

Find the location for the nine volt battery snap connector. Attach a solderless spade tongue terminal to each connector lead. Place the red lead terminal under the screw labeled S2. Place the black lead terminal under the screw labeled NO.

STEP 12

Strip 1/2" of insulation off each end of the two 12" long pieces of wire conductors. Crimp a solderless spade tongue terminal to each end of the two wires. Place one end of one wire under the screw labeled T1. Place one terminal of the other wire under the screw labeled T2. Connect the other two terminals to the magnetic switch.

STEP 13

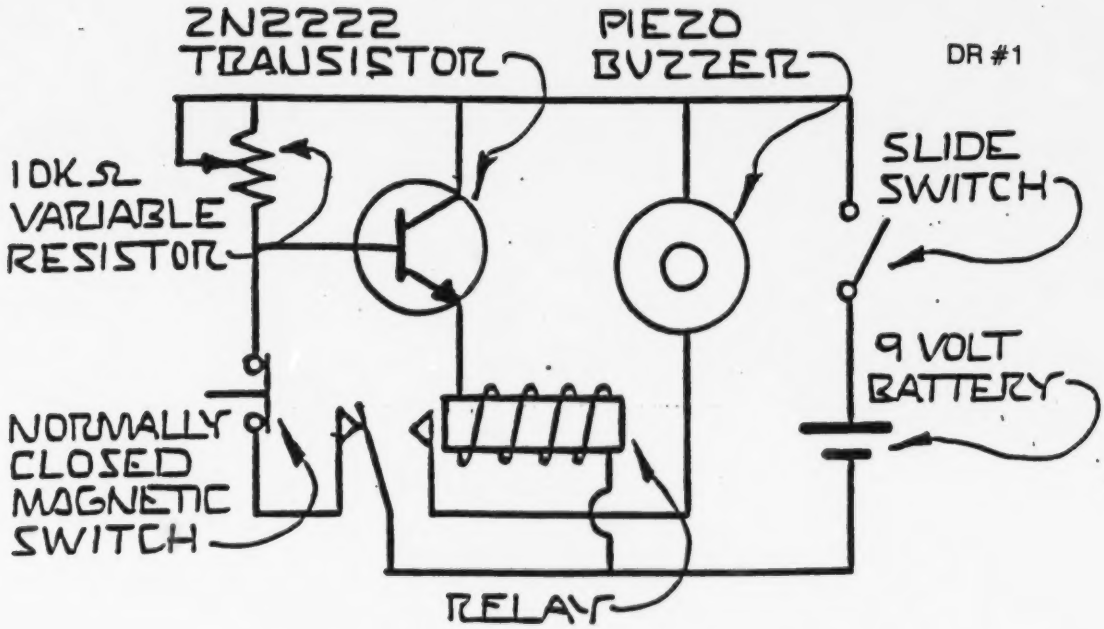
Carefully tighten each screw on the alarm unit and the magnetic switch (do not over-tighten). You do not want to distort the terminals.

STEP 14

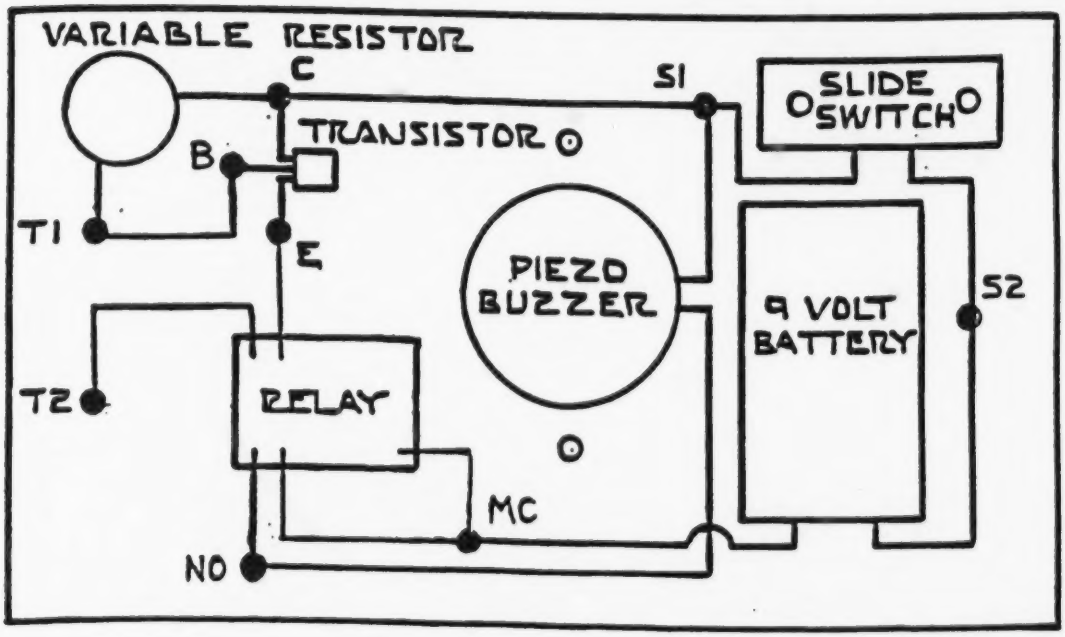
Carefully fasten the 9V battery clip in place and push the battery into the battery clip. Attach the battery lead snap connector to the terminal on the battery.

STEP 15

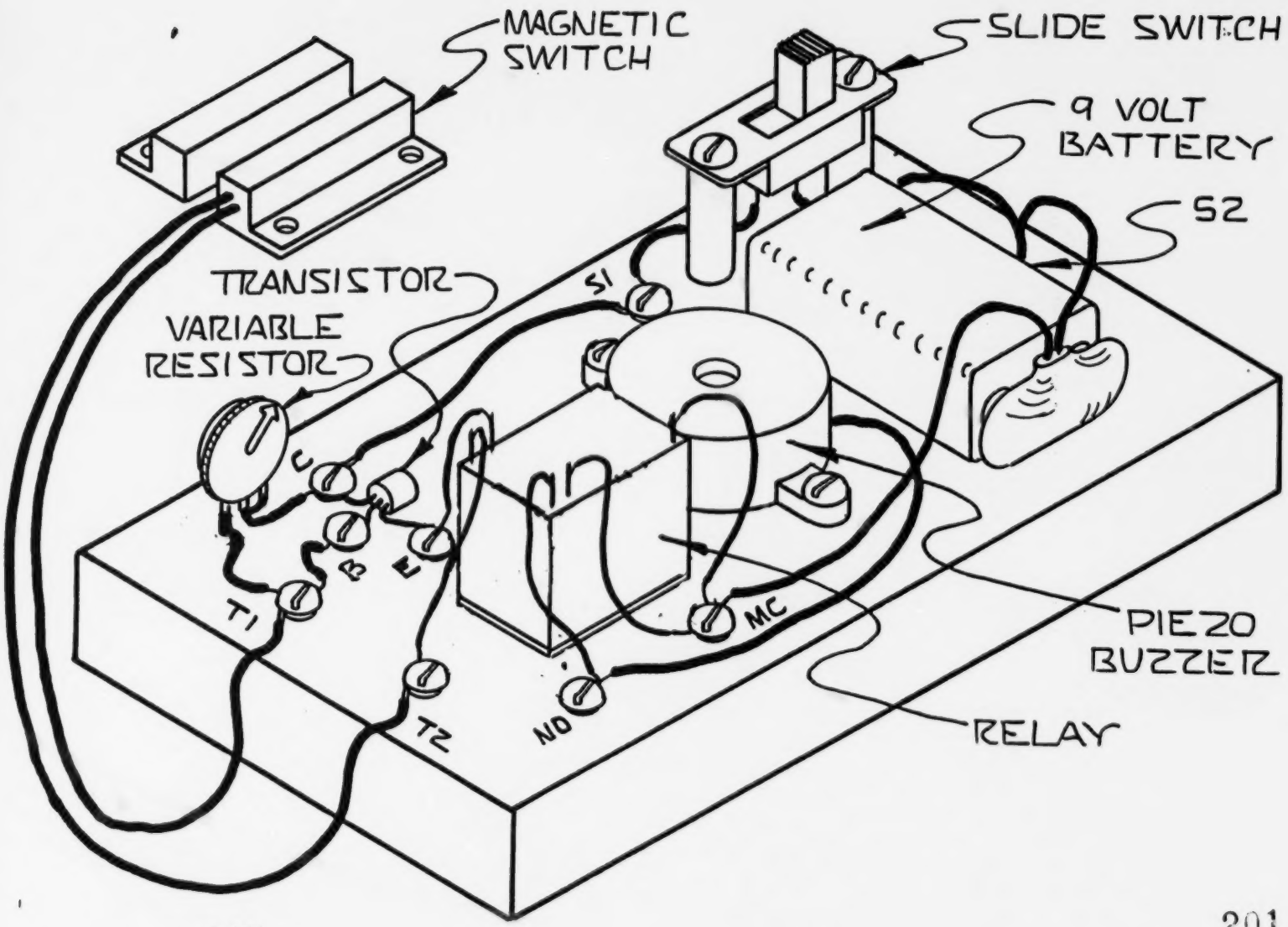
To test your burglar alarm, move the slide switch to its on position, and then separate the magnetic switch. The alarm should sound. If it does not, turn the variable resistor counter-clockwise until you hear the relay click and the piezo buzzer sound. If your alarm still does not work, check the switch, battery, and connections. If the alarm still fails to sound, ask your instructor for assistance.



Schematic for Model T-78 Alarm System



Template of Model T-79 Alarm System


MAGNETIC SWITCH
SLIDE SWITCH
9 VOLT BATTERY
S2
S1
TRANSISTOR
VARIABLE RESISTOR
C
B
E
T1
T2
NO
MC
PIEZO BUZZER
RELAY

DR #2

SERVICING
Estimating

Introduction:

In order to be successful, a firm or business must employ people with the knowledge to plan procedures and costs for doing a job, thus, providing the firm with an estimate of the amount of income that can be expected. It also provides the customer with a cost estimate in advance. In order to provide an accurate estimate, the estimator must determine the client's needs, and calculate the cost of the service. To do this, the estimator must effectively communicate with people, know how to read drawings or prints, be acquainted with different materials, and have an understanding of labor and overhead costs. Hence, the estimator must choose materials, calculate labor and overhead costs, and perform mathematical computations when preparing an estimate.

The process of estimation begins by first establishing the customer's needs, which will vary, depending on the service being offered. For example, if the service is building a room addition or installing a burglar alarm, the client may provide a drawing representing the customer's need. The estimator uses the drawing to create an estimate for the service. Now, let's say the service being offered is installing a central air condition system in an existing house. This may sound like the customer's need is simple; the customer wants an air conditioner. Does this change the role of the estimator? Most likely, yes. The estimator will have more direct interaction with the customer and will typically visit the client's residence to determine the appropriate air conditioning system. He/she will need to know the size of the house, what air duct system exists, what type of power is available, and how much the customer is willing to pay. The contracting firm then determines the type of materials needed to complete the job. The last area of concern is determining the amount of time needed to complete the installation job. This time element, multiplied by the labor cost per hour will determine the total labor cost of the job. Labor cost + materials + overhead + expected profit = cost to the customer. Since the firm may be in competition with others, it is important the customer knows exactly what type of service they are receiving and at what price. A competitor may provide a lower estimate but fail to include all the needed components to complete the job, or the contracting firm's estimate may be higher because the estimate included more components than the customer needed, thus, causing the estimate to be higher and forcing the customer to select another firm to provide the service.

This Technology Education Activity will provide students with the opportunity to use simple estimating concepts to develop an electrical estimate for a customer.

Materials and Supplies

- Rubber cement
- Scissors
- Chalk board or overhead projector
- Calculator
- Optional:
  - Sample alarm system components (e.g., switches, lights, warning decals)
  - Electronic component catalogs

Problem Statement:

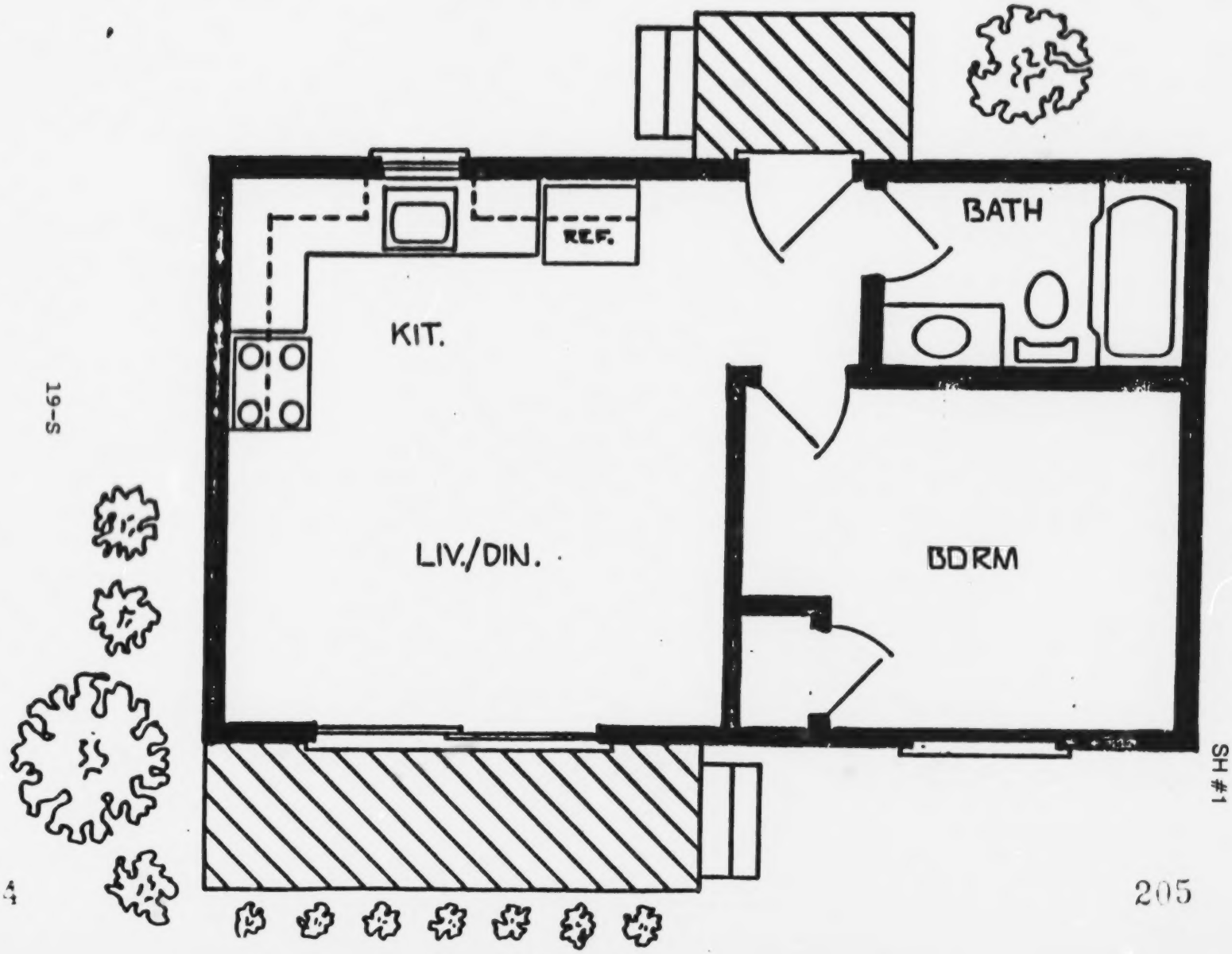
Estimating is an important part of any successful service-related business. If the estimate is too low, the company will not make a profit. If the estimate is too high, the company will lose business. Either situation could cause the company to go out of business. In this activity, you will develop an estimate for a new client. By completing the assignment, you will be exposed to the process and techniques used when estimating a service.

David Ryan is an out-of-state business person who has decided to build a vacation cottage. Mr. Ryan hopes to use the cottage for summer vacations with his family. The site for the cottage is in a remote area near a lake. Area residents have complained of houses being vandalized during the winter months. Knowing the cottage will be empty for long periods of time, Mr. Ryan has decided to invest in a security system. Since your company, ICU Security Systems, is in a town near the lake, Mr. Ryan has decided to ask your company for an estimate. Mr. Ryan has provided your firm a basic floor plan of the lodge (see SH #1). Mr. Ryan explains the cottage will have all the modern conveniences except for one. The cottage will not have a phone. He also explains his main concern is deterring intruders from entering the cottage. Mr. Ryan says he would like to have all exterior doors and windows secured by the alarm system and he is especially concerned with the securing a sliding glass door. He does not want the security system to interfere with his view of the lake. Mr. Ryan has expressed a need to be able to turn the alarm system off and on as he leaves or enters the cottage. Finally, he would like to have a panic switch located inside the cottage. The panic switch would be used if the Ryan family were occupying the cottage and an intruder tried to enter the house.

Based on the drawing and the information provided, it is up to your group to determine an appropriate estimate that meets Mr. Ryan's needs.

Activity Procedures:

1. Your instructor will divide the class into groups of two.
2. Obtain the drawing of the vacation cottage (SH #1), parts catalog (SH #2), and estimate sheet (SH #3) from your instructor.
3. Reread the scenario very carefully and look over the drawing of the cottage.
4. Using the scenario, the cottage drawing, and the parts catalog, determine the parts needed to install a security system. Remember it is not important to use all the components from the parts catalog. It is important to select components that will satisfy Mr. Ryan's needs.
5. Once your group has selected the appropriate parts, transfer the information to the estimate sheet. Be sure to carefully record the quantity needed, part number, item name, total material cost, estimated installation time, labor cost ($18.50 per hour), and total labor cost.
6. After you have recorded all the necessary data, calculate the total estimated cost of the job.
7. Next, obtain the student handout (SH #4) that shows all the security system components, scissors, and rubber cement from your instructor.
8. Using the cottage drawing and security system component sheet, cut and paste the layout of your proposed security system onto the drawing.
9. Once your group has completed the estimate and security system layout, present your ideas to Mr. Ryan (the rest of the class). Compare your estimate with the rest of the class.



VACATION COTTAGE

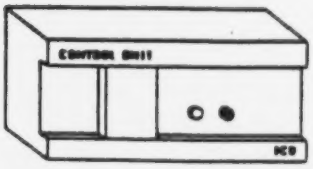
SH #1

S-61

19-S

PARTS CATALOG

Alarm Control Units

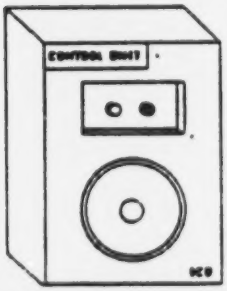


Part # 108A

Part cost $150.00/unit
Estimated Installation Time 60 min/unit

Detection Control Unit

Part Description: The Detection Control Unit is used to monitor and control the interior of a structure. The device can be programmed to alert the local police department by automatically sending an alarm over the phone lines when an intruder is detected. Using the same method, this system can alert the fire department in case of a fire. Using a touch-tone phone, the owner can call the unit, punch in his private code, and either activate or deactivate the system.



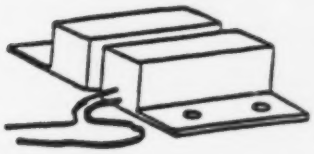
Part #108B

Parts cost $100.00
Estimated installation time 45 min.

Alerting Control Unit

Part Description: The Alerting Control Unit can be used to monitor and control the exterior perimeter of a structure. The unit comes complete with a built-in battery powered back-up system in case of a power failure, and a two-sound high efficiency siren to scare off intruders. The unit is designed to be mounted on the exterior of a structure and is built in a tamper-proof case. If an intruder is detected, the Alert Control Unit can be set up to send an ear piercing siren and/or activate flood lights.

Switching Devices



Part #221

Part cost $5.75/unit
Estimated installation time 20 min/unit

Magnetic Switch

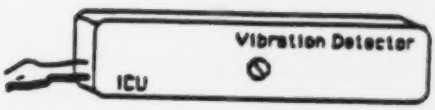
Part Description: The magnetic switch uses a magnetic field. If a door or window is opened, it breaks the magnetic field. When the magnetic field is broken, it opens the circuit and switches on the security system.

Part #222

Part cost $1.99/unit
Estimated installation time 35 min/unit

Contact Switch

Part Description: The contact switch is mounted against a door or window. If the door or window is opened, the pin is pushed out and opens the circuit, thus, activating the security system.



Part #223

Part cost #3.85/unit
Estimated installation time 30 min/unit

Vibration Detector

Part Description: The vibration detector senses movement. If an intruder causes a preset amount of vibration, the circuit will be broken and the security system activated. The sensitivity of the device can be adjusted.

Part #224

Part cost $5.99/120-ft 3/8" roll
Estimated installation time 25 min

Foil Vibration Detector

Part Description: The vibration foil is attached to glass. If the glass is broken or moved, the tape senses the motion and the system is activated.

Part #225

Part cost $7.95/unit
Estimated installation time 25 min/unit

Glass Breakage Detector

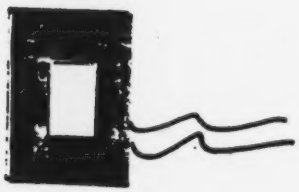
Part Description: The glass breakage detector monitors the surface of glass. If the glass is broken, the system will be activated. The device will protect up to 32 square feet.

Part #226

Part cost $34.95/unit
Estimated installation time 45 min/unit

Smoke/Heat Detector

Part Description: The smoke detector monitors for both smoke and heat. If the smoke/heat detector senses a temperature of over 190 degrees or the presence of smoke, the detector will set off an alarm and send a signal through the phone lines to alert the fire department.



Part #227

Part cost $1.78/unit
Estimated installation time 30 min/unit

Panic Switch

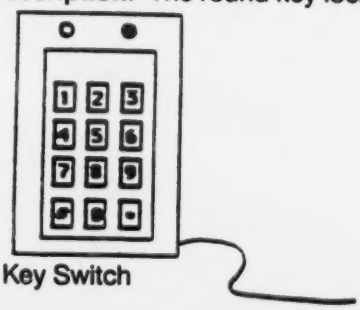
Part Description: The panic switch can be placed anywhere in the security system. If an intruder is detected, the panic switch can be pushed and the system will be activated.

Part #228

Part cost $9.95
Estimated installation time 40 min/unit

Round Key Lock Switch

Part Description: The round key lock switch is used to activate and deactivate the system.



Part #229

Part cost $21.95/unit
Estimated installation time 60 min/unit

Digital Key Switch

Part Description: The digital key system is a programmable switch. The switch will allow the user to enter a secret code to activate and deactivate the system.

Deterrent Devices

Part #441

Part cost $59.95/unit
Estimated installation time 60 min/unit

Dual Flood Lights

Part Description: The dual floodlights are wall-mounted units that can be activated when an intruder is detected or programmed to light automatically for a designated period of time. This type of lighting is used to light large areas.

Part #442

Part cost $21.99/light
Estimated installation time 20 min/light

Landscaping Light

Part Description: Landscape lights are typically installed at ground level and are used to light bushes, trees, shrubs, and walkways. The lights can be set up to either activate when an intruder is detected or programmed to light automatically for a designated period of time.

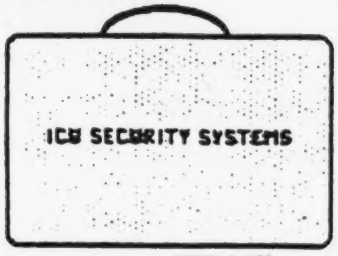
Part #443

Part cost $3.45/pack of ten
Estimated installation time 3 min/decal

Warning Decals

Part Description: The warning decals are used to alert potential intruders that a security system is in operation.

Installation Kit



Installation Kit

Part #333

Part cost $37.95

Part Description: The installation kit will include all the materials needed to hook up and connect a security system. The kit includes such items as wire, brackets, electrical tape, and fasteners. Each complete security system will require one kit.

Labor Cost is $18.50 per hour.

JOB ESTIMATE SHEET

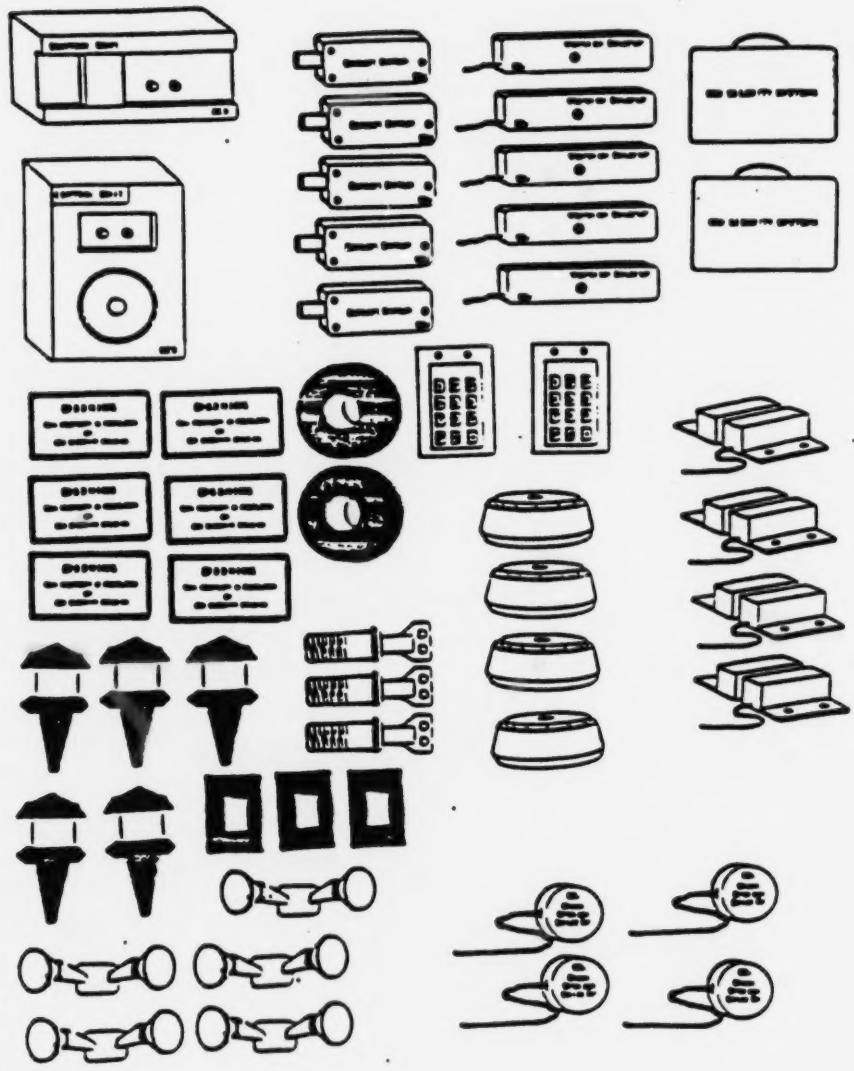
SH #3

ESTIMATOR _____ DATE _____

JOB NAME _____

MATERIAL COST					LABOR COST			TOTAL COST
Part #	Part Name	Quantity Needed	Part Cost Per Unit	Total Cost (Cost X Quantity)	Labor Cost/hr.	Est. Instal-lation Time	Total Labor Cost (Labor X Time)	Total Material Cost + Total Labor Cost

SECURITY SYSTEM COMPONENT SHEETS



SERVICING
Installing

Introduction

Many new products like air conditioners, computer systems, and car stereos require a specially trained person to install them. Installing is a post-production activity which takes a finished component, fixes it in place and hooks it up for original use. For example, an air conditioner is manufactured in a factory. After it is made, a service technician, using a work order, sets the unit in place, connects the cooling system and makes the electrical hook-ups.

This Technology Education Activity will expose students to the concept of installing by allowing them to install a security system for a fictitious client.

Materials and Supplies

Provide each group of two or three students the following materials:

- 1 Alarm control unit (DR #1)
- 2-3 switching devices (e.g., magnetic, contact, vibration)
- 1 Wall section mock-up (DR #2)
- Wire
- Screw drivers
- Wire strippers
- Wire cutters
- Electrical tape
- Soldering gun and solder
- Crimper
- Solderless spade tongue terminals

Problem Statement

Mr. David Ryan recently purchased a security system from ICU Security Systems. As a service technician for ICU, you will install Mr. Ryan's new security system.

Activity Procedures

1. Obtain the necessary materials to complete this activity from your instructor.
2. Study the work order provided (SH #1). Place the name of each group member in the section called Technician.
3. After reading the work order, study the component placement layout found on DR #2.
4. Determine the location of all the components of the security system.
5. Using the installation instructions found on the next page, install the Model T-78 Alarm System.

Model T-78 SecuritySystem

Installation Instructions

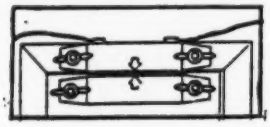
NOTE: DR #2 should be used as a guide for Steps 1 through 9.

STEP 1

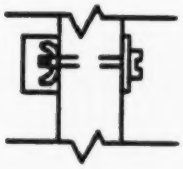
Locate the Model T-78 controller unit on the Alarm System Mock-up. Using the Alarm System Mock-up as a guide, install the controller unit onto the wall section. The controller unit can be fastened to the wall section with wood screws, velcro strips, or hung in place using cup hooks. Velcro strips have been used in this activity.

STEP 2

Locate the first magnetic switch on the Alarm System Mock-up. Notice it is located above the door. Carefully position the magnetic switches as shown below. Be sure to position the switch so the arrows on the switch are pointing toward each other. (NOTE: The stationary half of the switch containing the screws for the conductor connections should be positioned on the wall above the door.)

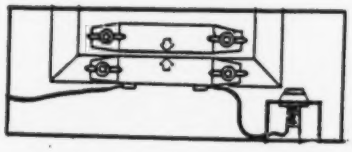


Using bolts and wing nuts, install the magnetic switch (see illustration below). (NOTE: Be sure not to over-tighten the wing nut. Doing so could damage the switch.) If the switch is being installed for the first time, pilot holes should be positioned and drilled.



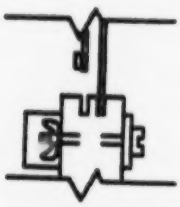
STEP 3

Locate the second magnetic switch on the Alarm System Mock-up. It should be located on the bottom part of the window. (NOTE: The window used in this activity is designed to simulate a double hung window. This activity can be changed or modified to accommodate other styles of windows.) Carefully position the magnetic switch as shown below. (NOTE: The stationary half of the switch containing the screws for the conductor connections should be positioned on the wall below the window.)



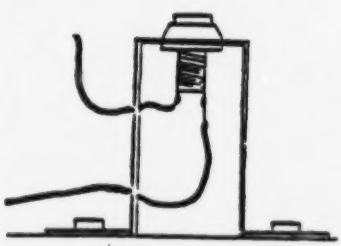
STEP 4

Using bolts and wing nuts, install the magnetic switch (see illustration below). (NOTE: Be sure not to over-tighten the wing nut. Doing so could damage the switch.) If the switch is being installed for the first time, pilot holes should be positioned and drilled. Spacers may be needed in order to keep the two parts of the switch even with each other.



STEP 5

Locate the panic switch on the Alarm System Mock-up. The panic switch should be located on the metal plate found in the lower right hand corner of the wall section. (NOTE: To make installation easier, it is advisable to solder leads to each of the posts located on the bottom of the switch [see illustration below]). One lead should be long enough to reach to the magnetic switch located on the window. The other lead should be long enough to reach back to the control unit.



Use the hardware provided with the switch to install the component to the metal plate.

STEP 6

Once all the hardware has been installed, install the wire conductors. All of the components in the system will be hooked up in series. The circuit will make a loop starting from T1 on the control unit through each of the switches and back to T2. (NOTE: Before connecting any conductors, be sure to turn off the switch on the controller unit and disconnect the battery, preventing the alarm from being activated before you are ready.) First, cut a wire conductor that will reach from T1 to the connection screw on the left side of the magnetic switch located on the door. Once cut, crimp a spade tongue terminal to each end of the wire conductor and attach them to the screws.

STEP 7

Cut another piece of wire conductor that will reach from the right hand lead screw of the magnetic switch on the door to the left hand lead screw of the magnetic switch located on the window. Once cut, crimp a spade tongue terminal to the end and install the wire.

STEP 8

Attach the short lead from the panic switch to the right side of the magnetic switch located on the window.

STEP 9

Connect the long lead from the panic switch to the terminal marked T2 on the control unit.

TESTING THE DETECTION CIRCUIT

STEP 10

Before testing, connect the battery, close the door and window, and push the panic switch to the closed position.

STEP 11

Begin by arming the system. Turn the slide switch on the control unit to the on position. (NOTE: Be sure that the panic switch is in the closed position or the alarm will sound when the system is activated.)

STEP 12

With the system armed, open the door as far as possible. The alarm should sound. Did it? (Yes or No) If yes, close the door, turn off the alarm system, and move to Step 13. If no, try the following:

- Check to see if the battery is connected properly
- Use a volt meter to check for sufficient battery voltage.
- Check the variable resistor on the control unit to see if it is adjusted properly.
- Check all connections.
- Check the magnetic switch to see if the arrows on the switch are pointing toward each other.
- Replace the switch and try the test again.
- Replace the control unit and try the test again.

STEP 13

The next step is to test the switch located on the window. Reactivate the alarm by turning on the control unit switch. (NOTE: Be sure that the panic switch is in the closed position or the alarm will sound). Once activated, raise the lower half of the window. The alarm should sound. Did it? (Yes or No) If yes, close the window, shut off the alarm, and proceed to Step 14. If no, try the following:

- Check to see if the battery is connected properly
- Using a volt meter, see if the battery is dead.
- Check the variable resistor on the control unit to see if it is adjusted properly.
- Check all connections.
- Check the magnetic switch (for proper installation) to see if the arrows on the switch are pointing toward each other.
- Replace the switch and try the test again.
- Replace the control unit and try the test again.

STEP 14

The last step is to check the panic switch. Begin by reactivating the system. With the alarm activated and the switch closed, push and release the panic button. The alarm should sound. Did It? (Yes or No) If yes, close the panic switch, shut off the alarm, and proceed to Step 15. If no, try the following:

- Check to see if the battery is connected properly
- Using a volt meter, see if the battery is dead.
- Check the variable resistor on the control unit to see if it is adjusted properly.
- Check all connections.
- Replace the switch and try the test again.
- Replace the control unit and try the test again.

STEP 15

Once all parts of the system are functioning properly, demonstrate the use of the system to your client, Mr. Ryan (your instructor). Be sure to explain how the system works, as well as, how to use it.

STEP 16

After Mr. Ryan (your instructor) has seen the system work, have him sign the work order to show the job has been completed.

ICU
WORK ORDER

TECHNICIANS: _____

_____

_____

Service to be Performed:

Install the Model T-78 Security System. Locate the controller unit to the left side of the door. Connect a magnetic switch on the door. Connect a magnetic switch on the lower half of the window. Locate and connect a panic switch in the lower right corner of the room. Finally, test the system.

SIGNATURE: _____

DATE: _____

Activity Analysis

1. Installing is a _____ activity which takes a finished component, fixes it in place and hooks it up for original use.

   A. pre-production
   b. post-production
   c. intermittent production

2. What impact could improper installation of components and/or equipment have on a service-related company?

   _____

   _____

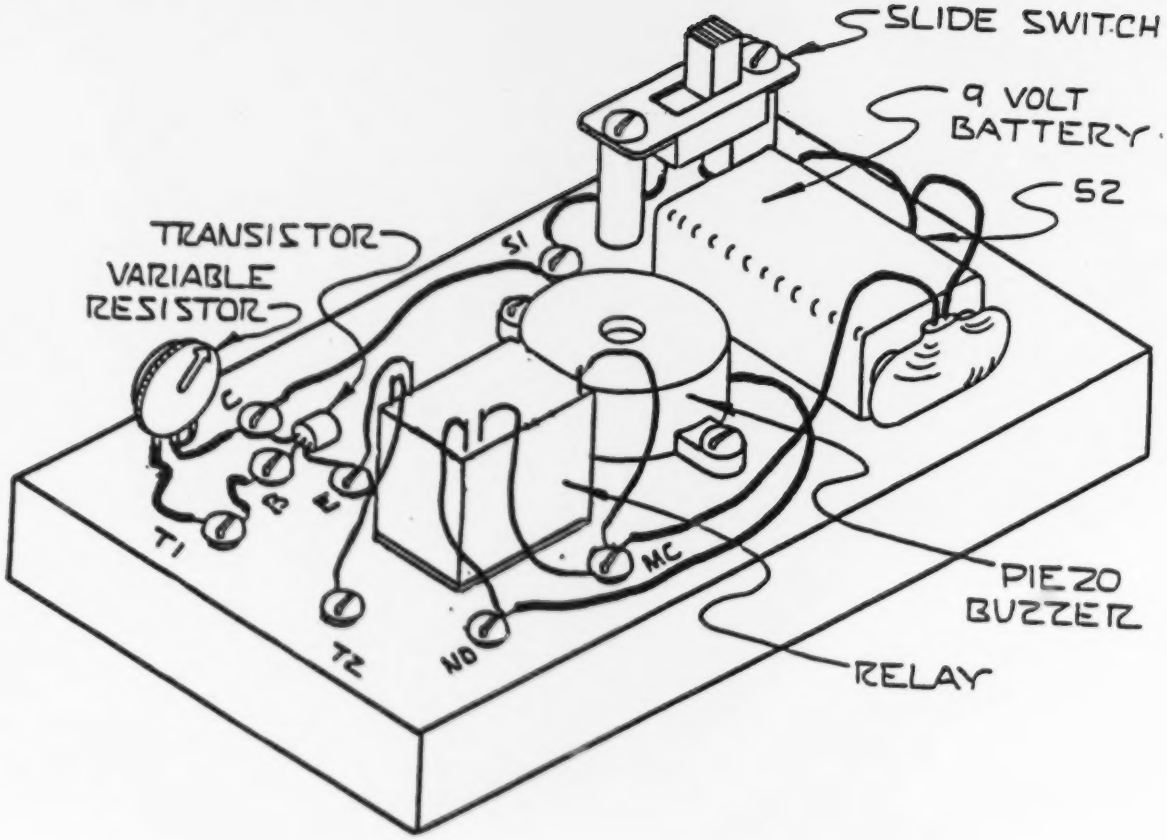
   _____

3. List three examples of products which require professional installation.

   _____

   _____

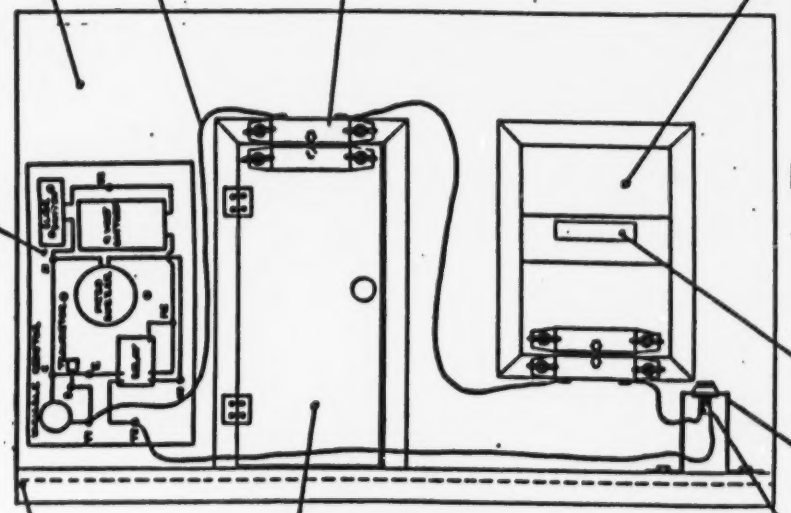
   _____



Controller Unit for Model T-78 Alarm System

Sample Model T-78 Alarm System Mock-up

36-S



The wall is a 3/4" x 10" x 16 3/4" piece of hardboard. The door opening is 5" wide and the rough window opening is 10 1/2" for the left end of the wall unit.

Wire conductors

Magnetic Switch attached with machine screws that go through the wall and held in place using wing nuts.

The rough window frame opening is 4 1/4" x 5 1/2". The window frame shown in the picture is designed to simulate a double hung window. The window frame has two 3/16" grooves spaced 1/8" apart. Two pieces of 1/8" plexiglass have been cut to fit into the grooves. The two pieces of plexiglass are 2 3/4" long. The width may vary, so cut to fit. The piece facing the inside of the house should fit loose enough to slide up and down. The piece facing the outside should be fixed in place.
(NOTE: Other styles of windows like casement windows can be simulated by simply using small hinges).

Controller Unit mounted with velcro

1/2" x 1/2" x 1 1/2" wooden handle for the window.

SPST Push Button Switch

A 1 1/4" wide piece of sheet metal with 3/8" hole centered in the top for the push button switch. The two bottom flaps are 1". The sides are 2" tall. The top is 1 1/4" long.

The base is a 3/4" x 3 1/2" x 16 3/4" piece hardboard. A 3/8" deep by 3/4" wide dado groove has been cut into the base 3/4" from one edge. The wall fits into this groove for stability.

The door opening is 3 3/8" x 7 3/8". A 3/4" piece of pine has been cut to fit the opening and held in place with 3/4" hinges.

DR #2

BEST COPY AVAILABLE

SERVICING

Maintaining

Introduction

Maintaining is another area of servicing, typically done to maintain or improve performance, prevent excess wear, or improve the looks of a product. A car engine, for example, may be tuned up in order to increase the gas mileage, or it may be maintained by changing the oil. The fresh oil lubricates the parts of the engine to prevent excess wear. The car may also be waxed to improve its appearance. Buildings also require maintenance. Painting, mowing, and window washing are examples of maintenance intended to improve the property's performance, prevent wear, and/or improve its appearance.

This Technology Education Activity is part of a series of activities, introducing students to the concept of maintenance by allowing them to conduct several simple preventive maintenance activities on a security system.

Materials and Supplies

Provide each student or group of two students the following:

- Installed security system mock-up (DR #1)
- Volt meter
- 9 volt battery

Problem Statement

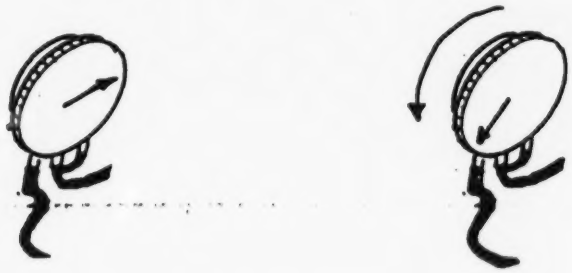
As part of his security system, Mr. Ryan has purchased a five-year preventive maintenance package that provides maintenance checks every six months for five years. The package includes a system test, inspection of the controller unit settings, and a check of the system's power supply. You and your partner will conduct the maintenance checks on Mr. Ryan's system.

Activity Procedures

1. Obtain an installed security system mock-up (see DR #1), a volt meter, and a 9 volt battery from your instructor.

2. Locate and remove the battery from the controller unit. Using the volt meter, load test the battery by connecting a small light bulb to the battery for five minutes. If the battery maintains a constant reading of 7 volts or more for a period of five minutes, then reinstall the battery and continue. If the battery fails to hold a charge or reads less than 7 volts, replace it with a new 9 volt battery. Then, continue with #3.

3. Locate the variable resistor (see DR #1). Turn the arrow to the 3 o'clock position (see illustration below). Activate the system. Then, open one of the switches. Now, slowly turn the dial on the variable resistor counter-clockwise until the alarm sounds (see illustration below).



4. Once the battery and variable resistor have been checked, test the system. This is done by arming the system, **(NOTE: Be sure the panic switch is closed or the alarm will sound)** and testing each alarm switch (e.g., door magnetic switch, window magnetic switch, panic switch). With the alarm activated, open the door. The alarm should go off. If the alarm does not sound, call in a technician to troubleshoot the system. If the alarm does sound, close the door and reactivate the system. Then, open the window. The alarm should sound. If the alarm does not sound, call in a service technician to troubleshoot the system. If the alarm sounds, close the window and reactive the system. Finally, push the panic switch. The alarm should sound. If not, call in a technician to troubleshoot the system. If the alarm sounds, close the switch and reactivate the system.
5. Report the results of the maintenance checks to Mr. Ryan (your instructor).

Activity Analysis

1. List three reasons why maintenance is done on industrial goods.
   a. _____
   b. _____
   c. _____
2. How can routine maintenance affect the life of a product or good?

_____

_____

_____

3. Describe some routine maintenance activity that could be performed on a video tape recorder (VCR) to maintain its performance, prevent excessive wear, and/or improve its looks.

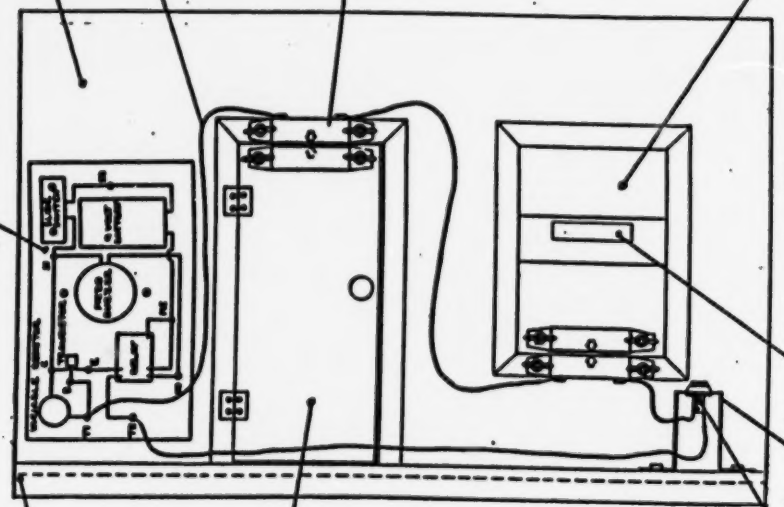
_____

_____

_____

Sample Model T-78 Alarm System Mock-up

40-S



The wall is a 3/4" x 10" x 16 3/4" piece of hardboard. The door opening is 5" wide and the rough window opening is 10 1/2" for the left end of the wall unit.

Wire conductors

Magnetic Switch attached with machine screws that go through the wall and held in place using wing nuts.

The rough window frame opening is 4 1/4" x 5 1/2". The window frame shown in the picture is designed to simulate a double hung window. The window frame has two 3/16" grooves spaced 1/8" apart. Two pieces of 1/8" plexiglass have been cut to fit into the grooves. The two pieces of plexiglass are 2 3/4" long. The width may vary, so cut to fit. The piece facing the inside of the house should fit loose enough to slide up and down. The piece facing the outside should be fixed in place. (NOTE: Other styles of windows like, casement windows can be simulated by simply using small hinges).

Controller Unit mounted with velcro

1/2" x 1/2" x 1 1/2" wooden handle for the window.

SPST Push Button Switch

A 1 1/4" wide piece of sheet metal with 3/8" hole centered in the top for the push button switch. The two bottom flaps are 1". The sides are 2" tall. The top is 1 1/4" long.

The base is a 3/4" x 3 1/2" x 16 3/4" piece hardboard. A 3/8" deep by 3/4" wide dado groove has been cut into the base 3/4" from one edge. The wall fits into this groove for stability.

The door opening is 3 3/8" x 7 3/8". A 3/4" piece of pine has been cut to fit the opening and held in place with 3/4" hinges.

DR #1

228

227

SERVICING
Repairing

Introduction

As goods and products age, they begin to break or wear out, requiring service or repair. Repairs on industrial goods are typically done by trained technicians who diagnose the problem. Diagnosing is the process of pinpointing the specific part or component that needs to be fixed. At times, this is a simple process. On the other hand, there are many times the process is more difficult. Technicians may have to refer to repair manuals, diagrams and/or use sophisticated equipment to locate the problem. A television, for example, may have the picture go out. A technician would need to test several components in order to pinpoint the problem. Once the problem has been identified, several corrective measures can be taken. The damaged good may need some type of adjustment. Gapping an automobile's spark plug or setting the vertical hold on a television are examples of adjustments. On the other hand, the good may have a part or component which is beyond repair and needs to be replaced. Replacing parts is the most common activity conducted by service technicians. Changing worn spark plugs, for example, is a servicing activity in which new parts replace old ones.

This Technology Education Activity is part of a series of servicing activities in which students will explore the concept of repairing by assuming the role of a service technician who repairs security systems.

Materials and Supplies

* Installed security system mock-up (DR #1)
* Continuity tester
* Volt meter
* Working alarm system controller unit (DR #1-2)
* Working magnetic and push button switches
* Fresh 9v battery
* Wire

Problem Statement

It has been several years since Mr. Ryan's security system was installed. Recently, the system has not been working properly. Mr. Ryan and his family are planning a long trip and before leaving, he wants to make sure the system is working. He has called ICU Security Systems to have his system checked. As a technician for ICU, it is your job to check the system and make any needed repairs.

Activity Procedures

1. Obtain the materials listed on the preceding page from your instructor.
2. Using the procedures described in the Model T-78 Service Manual (SH #1) diagnose and troubleshoot Mr. Ryan's security system (wall section mock-up).
3. Once the system has been checked and is working, complete a work order (SH #2) according to the steps listed below. Since Mr. Ryan's warranty has expired, he will have to pay for the service. The work order described below outlines the process for a customer who is not covered under a warranty. The work order lists the names of the service technicians, describes the service performed, and lists all parts and labor costs.

Step 1 — Write your name in the blank provided under "service technicians."

Step 2 — Complete the section titled **Customer Data**. This section includes the customer's name, address, city, zip code, phone number, signature, and date (see sample on SH #3). **Make sure the work order is signed and dated by your client (your instructor).**

Step 3 — Identify the parts you check and replace by putting a check mark in the blank next to each part or component (see sample on SH #3).

Step 4 — List all the labor costs in the labor column. Enter a $1.00 labor cost for every part you checked. Enter the labor cost shown below for every part you replace or adjust (see sample of SH #3).

	Labor Cost/Item
Magnetic switch	$ 6.20
Panic switch	9.25
Wire leads	3.00
Battery	2.00
Variable resistor adjustments	2.00
Controller unit	18.50

Step 5 — Referring to the list below, list the cost of each part replaced in the parts column (see sample on SH #3).

	Parts Cost
Magnetic Switch	$ 5.75
Panic switch	1.75
Wire leads	.25
Battery	2.75
Controller unit	100.00

Step 6 — Add all the labor costs together and enter the number in the blank labeled **TOTAL** at the bottom of the column marked **Labor** (see sample on SH #3).

Step 7 Add all the parts costs together and enter the number in the blank labeled **TOTAL** at the bottom of the column marked **Parts**(see sample on SH #3).

Step 8 Place the totals from Step 5 and 6 in the blanks provided in the section titled **TOTAL COST** (see sample on SH #3).

Step 9 Add the total labor cost to the total parts cost and enter the total in the blank next to Total Cost (see sample on SH #3).

Step 10 After completing the work order, give both the signed work order and the wall section mock-up to your instructor.

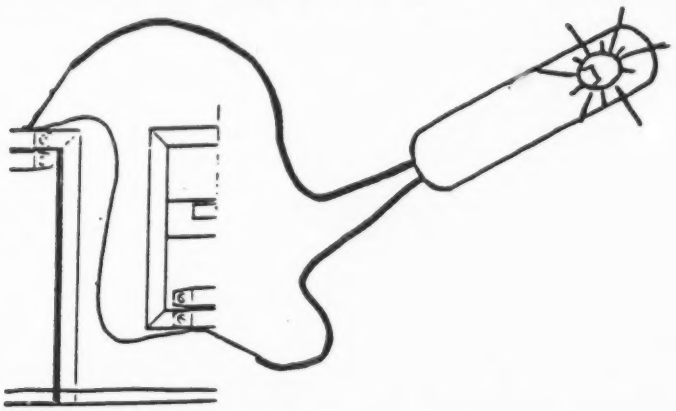
MODEL T-78 SECURITY SYSTEM

SERVICE MANUAL

Procedures for Troubleshooting

This manual contains the procedures needed to diagnose and troubleshoot the Model T-78 Security System, one of the most reliable security systems on the market. Even so, repairs are sometimes needed. By using this manual , most common problems can be identified and corrected.

You will use a continuity tester which checks the conductivity (the ability of electrons to flow between two points) of a circuit. There are two common types of continuity testers, one using a battery and light(as used in this activity), or a buzzer or bell. If there is conductivity between the two points, the light, buzzer, or bell will be activated. To check for conductivity, touch one end of the lead on the continuity tester to one end of the circuit to be tested, and the end of the other lead to the opposite end of the circuit. See example illustrations below. Once you understand how to use the continuity tester, it can be used to check the complete alarm system.



STEP 1

The first step in testing the Model T-78 Security System is to check the continuity of the system's detection circuit. First, disconnect the two leads on the controller unit at T1 and T2. (NOTE: Before testing, make sure the panic switch is in the closed position.)

Touch the ends of the continuity tester leads to the ends of the dectector circuit (the leads that were connected to T1 and T2). The light should come on. Does it? If **not**, there is a problem with the leads and/or the switches. If **yes**, it could mean the circuit is fine. It could also mean the wire conductors are okay but one or more of the switches are bad. To be sure the circuit is okay, each switch must be checked. Steps 2-4 discuss the procedures for checking the system if the continuity tester lights. Steps 5-14 discuss the procedures for checking the system if the tester does not light. If the tester fails to light, skip Steps 2-4 and go to Step 5. If the tester lights, continue with Step 2.

STEP 2

Check the magnetic switch on the door. Open the door as far as possible. Then, touch the end of one lead of the continuity tester to one of the magnetic switch's screw terminals. Touch the other tester lead to the other screw terminal. Does the tester light stay off? If yes, move on to Step 3. If no, replace the magnetic switch and retest before moving to the next step.

STEP 3

Check the window switch. Begin by opening the window as wide as possible. Then, check the conductivity between the two screw terminals on the magnetic switch. Does the tester light stay off? If yes, move on to Step 4. If no, replace the magnetic switch and retest before moving to the next step.

STEP 4

Check the panic switch. Begin by making sure the button is in the open or up position. Then, check the continuity between the terminals on the panic switch. Does the tester light stay off? If yes, this completes the process of checking the alarm circuit. Move down to Step 15. If no, replace the panic switch and retest. After retesting move down to Step 15.

STEP 5

Since the light did not illuminate, each individual component of the detection circuit must be checked. Start by checking the lead connecting T1 to the magnetic switch on the door. Begin by checking the continuity between the two ends of the wire. Does the light on the continuity tester come on? If yes, the wire is okay and move on to Step 6. If no, replace the wire and retest before moving to the next step.

STEP 6

Check the magnetic switch on the door. Each switch must be checked twice, once to see if the circuit remains closed when the switch is closed, and then again to see if the circuit opens when the switch is opened. Begin by closing the door. Then, check the continuity between the two screw terminals on the magnetic switch. Does the tester light come on? If yes, move to Step 7. If no, replace the switch and retest before moving to the next step.

STEP 7

Open the door as far as possible, then, repeat the test. Does the tester light stay off? If yes, move on to Step 8. If no, replace the magnetic switch and retest before moving to the next step.

Check the wire conductor between the magnetic switch on the door to the magnetic switch on the window. Does the light on the continuity tester come on? If yes, the conductor is okay and move on to Step 9. If no, replace the wire and retest before moving to the next step.

Check the magnetic switch on the window. Like the door switch, the window switch will need to be tested twice. Begin by closing the window. Then, check the conductivity between the two screw terminals. Does the tester light come on? If yes, move to Step 10. If no, replace the switch and retest before moving to the next step.

Open the window as wide as possible. Then, retest the switch. Does the tester light stay off? If yes, move to Step 11. If no, replace the magnetic switch and retest before moving to the next step.

Check the wire conductor between the magnetic switch on the window to the panic switch. Does the light on the continuity tester come on? If yes, the conductor is okay and move on to Step 12. If no, replace the wire and retest before moving to the next step.

Check the panic switch. Begin by making sure the button is in the closed or down position. Then, touch one lead of the continuity tester to one of the terminals on the panic switch. Touch the other tester lead to the other terminal. Does the tester light go on? If yes, go to Step 13. If no, replace the panic switch and retest before moving to the next step.

Open the panic switch. Retest using the process described above. Does the tester light stay off? If yes, move to Step 14. If no, replace the panic switch and retest before moving to the next step.

Check the continuity between the wire conductor between the panic switch and the screw labeled T2 on the controller unit. Does the light on the continuity tester come on? If yes, the conductor is okay. Reconnect the two ends of the alarm system to T1 and T2 on the controller unit. You are done checking the detector circuit. Move to Step 15 and begin checking the controller unit. (NOTE: Before moving on, make sure all the detection circuit switches are closed.) If the light stayed off, replace the conductor and retest before moving to the next step.

CHECKING THE MODEL T-78 CONTROLLER UNIT

STEP 15

Now that you have checked the detection circuit, test the controller unit. Disconnect and remove the battery from the controller unit. Using a volt meter, check the battery's ability to hold a charge. Load test the battery by connecting a small light bulb to the battery for five minutes. If the battery maintains at least 7 to 9 volts for five minutes, it is considered good. Is your battery good? If yes, move to Step 16. If no, replace the battery and retest before going to the next step.

STEP 16

Check the variable resistor. Move the dial so that the arrow points to the 3 o'clock position. Activate the system and open one of the switches (e.g., door, window panic). Slowly turn the dial counter-clockwise. Does the alarm activate? If yes, move to Step 17. If no, replace the controller unit and retest before moving to the next step.

STEP 17

After both the detection circuit and controller unit have been checked, reactivate the system and test the alarm. If the alarm fails to work, recheck the whole system again.

STEP 18

Once the alarm system is working properly, complete the work order (SH #2).

ICU
WORK ORDER

TECHNICIANS: _____

_____

_____

THE PROBLEM: _____

_____

			COST	
Magnetic switch	_____	_____	_____	_____
Panic switch	_____	_____	_____	_____
Battery	_____	_____	_____	_____
Controller unit	_____	_____	_____	_____
Wire Lead 1	_____	_____	_____	_____
Wire Lead 2	_____	_____	_____	_____
			TOTAL _____	TOTAL _____

CUSTOMER DATA

NAME _____

ADDRESS _____

CITY _____ ZIP _____

PHONE _____

SIGNATURE _____ DATE _____

TOTAL COST

Labor _____

Parts _____

Total Cost _____

ICU
WORK ORDER

TECHNICIANS: Jim Jones
John Brown
Mary Smith

THE PROBLEM: Troubleshoot the complete system to make sure all components are working properly.

			COST	
Magnetic switch	✓		1.00	
Panic switch	✓	✓	9.25	1.75
Battery	✓		1.00	
Controller unit	✓		1.00	
Wire Lead 1	✓	✓	3.00	.25
Wire Lead 2	✓	✓	3.00	.25
			TOTAL $18.25	TOTAL $2.25

CUSTOMER DATA

NAME David Ryan

ADDRESS 121 Pine

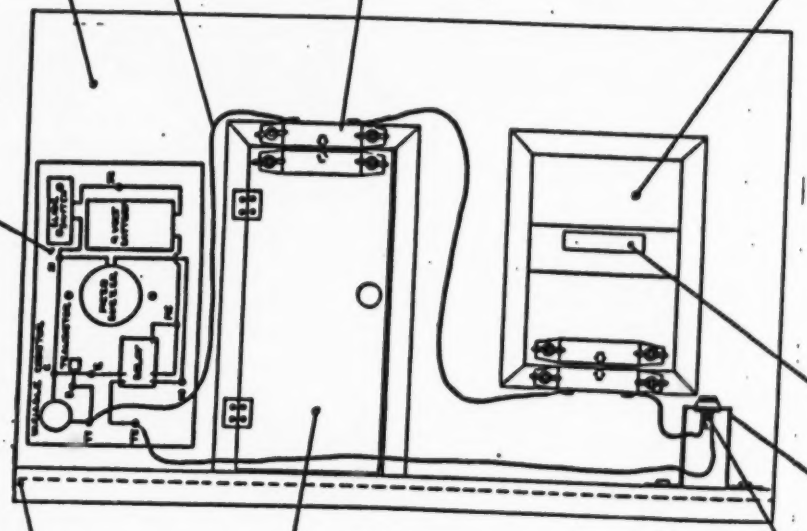
CITY Lake Brook ZIP 22111

PHONE N/A

SIGNATURE _____ DATE _____

TOTAL COST

Labor	$18.25
Parts	2.25
Total Cost	$20.50



The wall is a 3/4" x 10" x 16 3/4" piece of hardboard. The door opening is 5" wide and the rough window opening is 10 1/2" for the left end of the wall unit.

Wire conductors

Magnetic Switch attached with machine screws that go through the wall and held in place using wing nuts.

The rough window frame opening is 4 1/4" x 5 1/2". The window frame shown in the picture is designed to simulate a double hung window. The window frame has two 3/16" grooves spaced 1/8" apart. Two pieces of 1/8" plexiglass have been cut to fit into the grooves. The two pieces of plexiglass are 2 3/4" long. The width may vary, so cut to fit. The piece facing the inside of the house should fit loose enough to slide up and down. The piece facing the outside should be fixed in place. (NOTE: Other styles of windows like, casement windows can be simulated by simply using small hinges).

Controller Unit mounted with velcro

Sample Model T-78 Alarm System Mock-up

50-S

1/2" x 1/2" x 1 1/2" wooden handle for the window.

A 1 1/4" wide piece of sheet metal with 3/8" hole centered in the top for the push button switch. The two bottom flaps are 1". The sides are 2" tall. The top is 1 1/4" long.

SPST Push Button Switch

The base is a 3/4" x 3 1/2" x 16 3/4" piece hardboard. A 3/8" deep by 3/4" wide dado groove has been cut into the base 3/4" from one edge. The wall fits into this groove for stability.

The door opening is 3 3/8" x 7 3/8". A 3/4" piece of pine has been cut to fit the opening and held in place with 3/4" hinges.

DR #1

BEST COPY AVAILABLE

Controller Unit for Model T-78 Alarm System

51-S

DR #2

SERVICING SMALL ENGINES
Supplementary Servicing Activity

Introduction

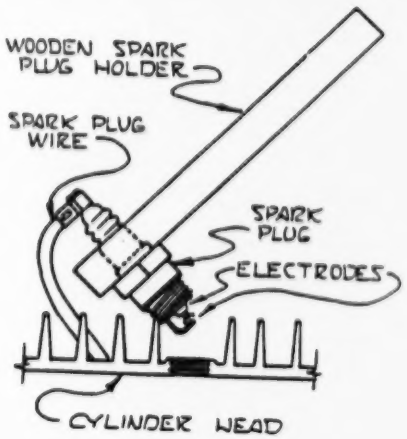
Problem Statement

You are a service technician at Bob's Engine Service. Your company services small engines. When a defective engine is brought to your service center, it is taken off the lawn mower and given to you to service. Follow the steps below to diagnose and repair your assigned engine. When you have finished, have the service manager (your teacher) check your work before you test the engine. Once the engine is working properly, complete the work order.

Materials and Supplies

Activity Procedures

1. The first step when servicing a small engine is to check the ignition system. Begin by carefully disconnecting the spark plug wire. Using a spark plug socket and a socket wrench, carefully remove the spark plug. To remove the spark plug, you will need to rotate the socket wrench counterclockwise. After you have removed the spark plug, reconnect the spark plug wire. Using a wooden spark plug holder, hold the base of the spark plug against the top of the cylinder head (see Figure #1). Pull the starter cord and watch for a spark between the electrodes. If you observed a spark, proceed to step two.



TESTING THE IGNITION SYSTEM

Figure 1

If you did not see a spark jump between the electrodes, replace the spark plug. Repeat the ignition check with the new spark plug. If you observe a spark jump between the electrodes on the new spark plug, proceed to step two. If you do not observe a spark jump across the electrodes, ask the service manager (your teacher) for assistance.

2. Disconnect the spark plug wire from the working spark plug. Put the spark plug in a location where it will not be damaged. Carefully insulate the terminal at the end of the spark plug wire with electrical tape. Place your thumb over the top of the spark plug hole (see Figure #2). Make sure you apply enough pressure to create a tight seal. Pull the starter cord.

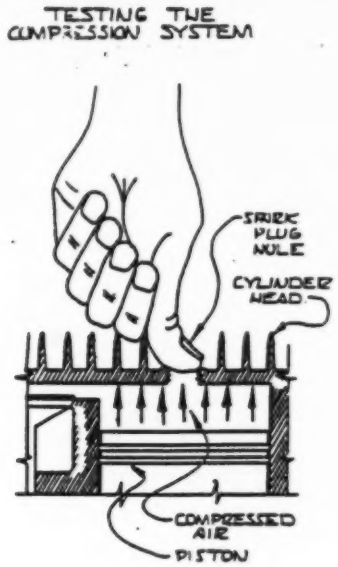


Figure 2

If you feel compressed air against your thumb, proceed to step three. If you do not feel compressed air, use the correct size socket and socket wrench to remove the bolts securing the cylinder head (see Figure #3). After the bolts have been removed, carefully lift the cylinder head off the engine block. Inspect the head gasket. If it is damaged, replace it with a new gasket. If you cannot find any defects, ask the service manager (your teacher) for assistance.

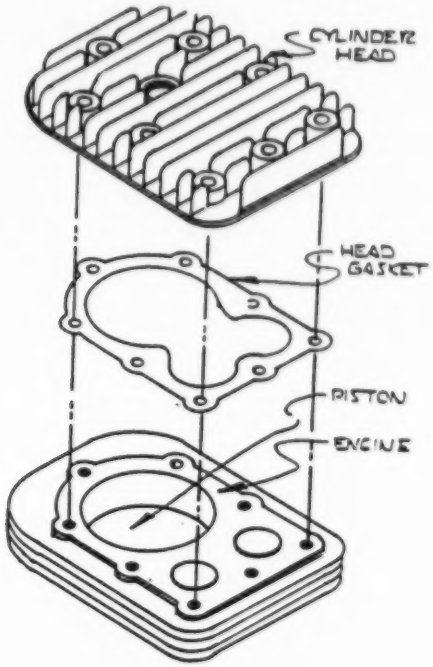


Figure 3

Position the new head gasket on top of the engine block so all the holes line up. Carefully put the cylinder head on top of the gasket and engine block. Reinstall the head bolts and make sure you tighten them in the order your teacher demonstrated. Do not overtighten the cylinder head bolts. Repeat the compression test with your thumb. If you feel compressed air against your thumb, proceed to step three. If you still do not feel compressed air, ask the service manager (your teacher) for assistance.

3. With the spark plug still removed, check the fuel system. Place your thumb over the spark plug hole (see Figure #4). Again apply enough pressure to create a tight seal. Pull the starter cord. Remove the thumb, hold it to your nose, and give it a sniff. If you smell gas, proceed to step four.

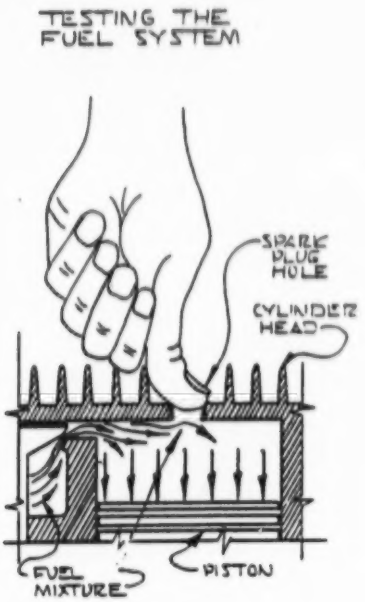


Figure 4

If you do not smell gas, check the idle fuel screw and/or main fuel screw (see Figure #5). Using a screw driver, you should be able to turn both screws one quarter turn in either direction. If the screws will not turn clockwise, adjust them counterclockwise according to your teacher's instructions. After the adjustments have been made, proceed to step four.

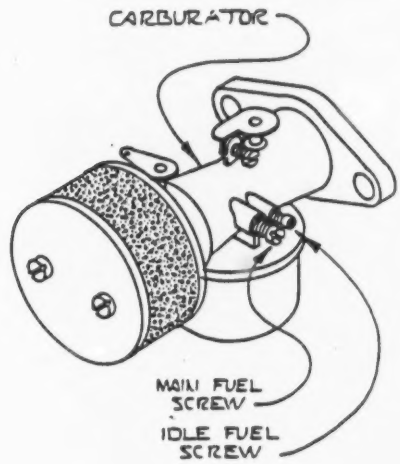


Figure 5

4. Install the good spark plug by hand. Twist it counterclockwise until it is snug. Using a spark plug socket and socket wrench, tighten the spark plug according to your teacher's instructions. Do not overtighten the spark plug. Carefully remove the electrical tape insulating the terminal at the end of the spark plug wire. Reconnect the spark plug wire to the spark plug.

5. Ask the service manager to approve your repairs. List the test you performed, the parts you replaced, and the adjustments you made. After your work has been completed, move your engine to the test area according to your service manager's (your teacher's) instructions. Check the oil level to make sure it is safe to start the engine. After you have made a final inspection, start the engine. Make sure you follow all the safety rules for operating an engine. Make whatever final adjustments are necessary. Once your engine has been tested and is working properly, proceed to the section on completing the work order.

Completing the Work Order:

The work order describes the service for which the customer will pay. It lists the names of the service technicians, describes the service performed, and lists all the parts and labor costs.

1. Begin completing your work order by writing your names in the blanks provided under "Service Technicians."

2. List the labor cost for each system checked and each part replaced. Enter $1.00 in the Labor column for each system checked. Enter $2.00 in the Labor column for each part replaced (see the example work order).

3. List the cost of each part replaced in the Parts column. Refer to the list below for the cost of each part.

   Spark Plug $1.00
   Head Gasket 2.00

4. Add all the Labor costs together and enter the total in the blank next to Labor.

5. Add all the Parts costs together, and enter the total in the blank next to parts.

6. Add the total cost of Labor to the total cost of Parts and enter the total in the blank next to total.

7. Give both the repaired product and the completed work order to the service manager (your teacher).

BOB'S ENGINE SERVICE

Work Order

Service Technicians:

_____

_____

_____

The Problem:

_____

_____

LABOR	COST	PART	COST
Checked ignition	_____	Spark Plug	_____
Checked Compression system	_____	Head Gasket	_____
Checked fuel/air system	_____		
Adjusted fuel/air system	_____		

LABOR _____

PARTS _____

TOTAL _____